SCIENTIFIC AMERICAN SUPPLEMENT. № 1596

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Scientific American, established 1845.
Scientific American Supplement, Vol. LXII., No. 1596.

NEW YORK, AUGUST 4, 1906.

Scientific American Supplement. $5 a year.
Scientific American and Supplement. $7 a year.

ELECTRICALLY-OPERATED COKE-DRAWING MACHINES.*

By Frank C. Perkins.

The accompanying illustration shows the details of construction and the method of operation of a new coke-drawing machine in use at the Continental plant at Uniontown, Pa. This machine, which was placed in operation by the H. C. Frick Coke Company, includes two independent units, the one a conveyor and the other an extractor, mounted on separate trucks and connected together by a link and pin coupler. The extractor comprises a heavy rigid cast-iron frame mounted on a pair of axles, which are driven by means of worm gearing, and it includes the necessary gearing for transmitting the power required for the various operations, carrying on the top a swing carriage through which passes a steel ram bar 4½ inches in diameter. A 20-horse-power motor is used for driving the main shaft through gearing. The motor is connected with a clutch, so that the ram may be moved forward and back in the oven. This motor is of the General Electric type of series machines, operating at a speed of 350 revolutions per minute on a circuit of 220 volts. The ram is provided with cut teeth on one side engaging with a steel pinion on a vertical shaft, which is driven by means of bevel gears from the main shaft.

A heavy chilled cast-iron shovel, which has a thickness of 6 inches at the back end and tapers down to a thin edge at the front, is mounted at one end of the ram, with sufficient length to carry the shovel to the back end of the oven, as shown in the accompanying illustration. The electric motor not only drives the main shaft, but is also arranged to propel the machine along the track when so required, the motor being handled by means of a Westinghouse controller. A handwheel and screw may be manipulated to rotate the swinging head and ram at any angle, in order to clean the sides of the oven. For the operation of the extractor two levers and a hand wheel are provided, the latter being used for operating the head, and the former, one for moving the controller and the other the clutch.

The other part of this interesting machine for drawing coke from beehive ovens is the conveyor, which really consists of two parts, carried by a steel framework which is mounted on wheels and coupled to the extractors. One of the two conveyors receives the coke in front of the oven as it is drawn out by the extractor, and delivers the material to the second conveyor, which loads it into the cars after properly screening it. The first conveyor, in front of the oven, has curved overlapping slats attached at each end to a heavy link belt running in a channel and protected from wear due to the coke dust. The other conveyor to the cars is also provided with narrow slats, which do not overlap as in the case of the first conveyor, the dust and ashes being screened out through the openings. This conveyor frame is hinged at the outer end, and is lowered and raised as desired for the proper height of cars by means of a small winch or hoisting machine, which is operated by a G. E. direct-current motor of 7½ horse-power operating at a speed of 690 revolutions per minute from the 220-volt power circuit. The main driving shaft is operated by means of this motor through a gear and pinion with two sprockets having chain drive, communicating power to the two conveyors.

This interesting machine was constructed at Covington, Va., by the Covington Machine Company, and is a great labor-saving device, only five men being required to work the machine to its full capacity, handling thirty to forty ovens per day for ten hours. The machine is placed in front of the ovens, so that the center one may be drawn out first when it is finally moved along the track, the ram being swung around to reach the sides. As will be noted by the accompanying illustration, the wedge-shaped shovel is driven by the electric motor under the coke, and after being pushed under, raises and separates it so that it falls behind the shovel, and is drawn out by the same on the return stroke, when the motion is reversed. The electrically-driven conveyors are arranged automatically to follow the operation of the extractor in all its positions, a single operator having the entire machine under control at all times, his assistants being required to move the cars, to water down the oven, and to clean the remnant of coke left by the machine.

Very careful tests were made at the Continental plant at Uniontown of the electric power required for operating this coke-drawing machine, and the following data may be of interest. The average voltage on the conveyor was 210, while the average current used in the extractor was 170 volts, 16 amperes being consumed by the conveyors, and 30 amperes being the current consumption on the extractor. The total average electrical power required was 2.2 kilowatts per hour, while the average time of drawing was a trifle over a quarter of an hour.

The average consumption for the conveyor was 3.36 kilowatts, while that for the extractor was 5.1 kilowatts for the extractor arm, and 8.5 kilowatts while shifting the machine from one oven to the other. At the beginning of the forward stroke of the extractor arm there is a momentary demand on reversal of 60 amperes, which drops almost instantly to 35 amperes, and finally to 26 amperes, as the extractor moves forward. The demand rises to 45 amperes, due to extra compression of the coke at the back end of the oven, toward the end of the stroke, where there is but small clearance. The current then rises to 45 amperes as it is reversed at the beginning of the return, dropping gradually at the end of the stroke to 22 amperes. One would ordinarily expect that the conveyor would require practically a steady current, but there is a heavy drawing of current with each reversal of the extractor, of 16 amperes decreasing to about 6 amperes as a normal demand.

It is maintained that the cost of operation is about 7 cents per oven for the power alone, with an average of 2.2 units at a rate of 2 cents per unit in addition to $1 per horse-power demand per month. It is stated that the labor of the operator is 7½ cents per oven, a full day drawing thirty ovens costing $2.25. Taking into account the labor of one helper, two hosemen, and other labor required, the total cost is said to be 42 cents per oven; while before this most interesting labor-saving device was introduced, the cost ranged from two to three times this amount. The saving of one-half dollar per oven on a large plant of several hundred ovens means quite an economy over previous methods, while there is a considerable saving of heat as well, as the ovens are opened only about one-third of an hour to draw out the old charge and refill with the new. It is also maintained that it is easier to get men to run this type of machine than to obtain labor willing to stand the terrific heat and hard work of drawing the ovens by hand. It is maintained that the coke is equal to that drawn by hand, with no more breakage, and fewer black ends, while deep charges can be handled as readily as smaller ones.

In some places, instead of using electric power, steam power is substituted. In that case a heavy vertical engine with double cylinders is employed, and the cranks set at an angle of 90 degrees with each other, in order to avoid dead centers. In such cases the engine is started, stopped, and reversed by a single

ELECTRICALLY-OPERATED COKE-DRAWING MACHINE.

* Specially prepared for the Scientific American Supplement.

lever, and a similar engine is utilized to drive the conveyor. But this machine is controlled by a governor, and runs at a constant speed. The working parts are run in a bath of oil, and inclosed in an oil-type dust-proof casing. As with all of the other modern electrically-operated labor-saving devices, not only is a great deal of time saved, but the output is greatly increased as well, and the ovens are worked to their fullest capacity.

THE PRESENT STATUS OF THE TURBINE AS APPLIED TO MARINE WORK.*

By HERBERT C. SADLER.

THROUGHOUT the history of shipbuilding, the attainment of speed, whether high or low, has been one of the fundamental requisites of every design. Depending, as it does, upon so many other conditions, it may not be out of place to repeat, in a general way, the problem that the naval architect must solve.

A floating structure is to be designed which will carry besides its own weight, a certain weight of cargo, must move at a certain speed for a certain time, i. e., must have a certain weight of machinery and fuel, and, finally, must carry this total burden upon a certain draft of water, and do so with safety. It is evident, therefore, that the question of displacement or weight is one of the primary conditions of design.

A discussion upon the resistance of ships is beyond the scope of this paper, but it may be observed that, in general, the less the weight of a vessel the greater the speed obtained with a given horse-power. Attention may also be called to the fact that whereas, in high-speed vessels, the weight of machinery and coal may be from 30 per cent to 50 per cent of the total displacement, in one of the cargo or intermediate type, this will range from 5 per cent to 20 per cent. This latter consideration has a very important bearing upon the type of propelling machinery that should be adopted in any given case, and, therefore, immediately affects the subject of this paper.

The requirements that should be fulfilled in any marine propelling instrument are necessarily diverse, depending upon the particular trade or occupation of the vessel. There are, however, certain broad conditions that should be fulfilled by all.

The first and most important is that of *reliability;* this term being taken to mean that the engine will run at its full power for long periods of time with minimum risk of breakdown. The modern marine engines of the ocean liners are prominent examples of what can be done in this respect; but it should be borne in mind that perfection is impossible of attainment, and occasional accidents necessarily unavoidable. In the merchant marine the failure of the machinery means a loss of time and, hence, money, sometimes a considerable amount, if the vessel is not under control. In war vessels the failure of the machinery at a critical time may turn what would otherwise have been a victory into defeat. Even in pleasure crafts an accident to the machinery may sometimes be accompanied by serious complications. In all, however, the danger of total loss is increased if the vessel be rendered helpless through the breakdown of her machinery.

The second requirement should be one of *economy.* This question is brought home to the naval architect and ship owner more forcibly than to any other designer or power user. From the naval architect's standpoint economy means that a smaller weight of fuel and water is required and hence a saving made in weight and power. To the owner economy not only means a reduction of running expenses, but also decreased first cost, because a smaller vessel may be designed to do the same work as a larger and less economical one.

In war vessels economy means many things, among which may be mentioned increased fighting power or protection, increased speed, or increased radius of action at the same speed.

The third condition should be one of *adaptability* to conditions of propulsion and maneuvering. The almost universal propelling instrument is now the screw, exception being made of the paddle wheel, the application of which is limited to special types of vessels. The marine engine, therefore, must be capable of running at fairly high speeds of revolution, but the screw propeller again sets an upper limit upon the revolutions beyond which it is undesirable to go. When the phenomenon of cavitation appears, the efficiency of the screw falls off rapidly, and hence very high speeds of revolution are inadmissible. High speed is also accompanied by small diameter of propeller, the diameter varying inversely as the revolutions. Small propellers are, in general, less efficient than large ones, but there are some compensations in the way of better immersion in cases of light draft and in a seaway, which, to a certain extent, counteract some of the disadvantages.

Another condition of importance is that of maneuvering. A marine engine should be capable of being stopped, started and reversed without difficulty, and by the simplest possible means. In certain cases where the service requires that the vessel should make a number of stops at short intervals, this condition is of primary importance.

In war vessels, also, maneuvering qualities require special attention; but in the case of the average merchant vessel whose trade requires long periods at full speeds and only short ones of backing and handling at each end of a voyage, the above condition does not occupy such a prominent place.

The fourth condition, and one to which attention has already been called, is one of *weight.* The weight per horse-power developed should be, in a marine engine, as small as possible consistent with good design. Here again the importance of this depends upon the conditions of service and type of ship; for in cases where the weight of engine is only, say, 5 per cent of that of the total vessel, a small percentage saving does not appreciably affect the result; whereas in those cases where this weight is in the neighborhood of 25 per cent of the total, even a small percentage saving may be accompanied with considerable advantages.

Closely connected with the above is the question of the space occupied and general dimensions of the engine. In a large majority of engines, any saving in space occupied by machinery is a distinct advantage; while in war vessels in particular, the necessity for protection demands an engine whose dimensions in the vertical direction are not excessive.

The final condition and one to which particular attention has been paid in the past few years, is that there should be no unbalanced force tending to produce vibrations when the engine is running.

With this brief *résumé* of the prominent conditions to be fulfilled by a marine engine, let us proceed to consider in what respects the steam turbine is suitable and wherein it falls short of the requirements.

There are two principal types of turbines, known respectively as the impulse and reaction turbine. These are distinguished by the pressure existing in the clearance spaces between the guide and rotating blades. If this pressure is greater than that of the steam as it leaves the rotating blades, the turbine is said to be of the reaction type, and if equal, the impulse type. There are many other classifications, but at present we need only consider those that have been used to any extent in practice.

As representing the two systems, the De Laval and the Parsons may be said to be typical. The De Laval turbine has one practically insurmountable difficulty, so far as its application to marine work is concerned, and that is its high speed of revolution. In order to bring this within reasonable limits it is necessary to introduce gearing. The high speed at which this gearing must run causes the marine engineer to pause before installing an engine of this type; in fact, high-speed gearing is a method of transmission of energy that should never be used in marine work.

In the Curtis turbine, which is practically a combination of the two systems, i. e., alternate pressure and velocity stages, the number of revolutions has been materially reduced. This turbine, although extensively used on land, has had, up to the present, only a limited application in marine work, so that experience with this particular type is somewhat lacking. There seems to be no reason why, with experience, the Curtis turbine should not be a success when applied to ships.

The success of the turbine in its application to marine work has so far been due entirely to Mr. Parsons, and, as the experience with this type of turbine is the greatest, the remainder of the discussion will be devoted to the application of this particular type.

Taking the conditions previously discussed, in order, the first requirement laid down was that of reliability. In any type of machine, one measure of the risk of breakdown is the number of moving parts. Other things being equal, a large number of joints, moving parts, rubbing surfaces, bearings, etc., is accompanied with a greater chance of stoppage of the whole machine through the failure of one, than where these are reduced in number. In the reciprocating engine the number of parts is unavoidably large, and sometimes an insignificant breakage or overheating may cause a temporary stop. From this point of view the turbine possesses a great advantage in that, so far as the engine itself is concerned, practically the two main bearings are all that require attention. With the present system of forced lubrication this difficulty has been almost eliminated.

The perfect balance and uniform twisting moment, possible with the turbine, also play a somewhat important part in this connection. Up to the present, experience with the turbine in marine work over very long periods has not been possible; but, judging from vessels already running, notably the "Turbinia," the first vessel to be installed with her present turbines in 1896, and also from the performances of similar land engines, there seems to be no reason for apprehension that the turbine should be inferior to any other type of engine. Certain difficulties have, no doubt, occurred, which with a new type of engine it was almost impossible to foresee, but once these are known their solution should not offer any serious difficulties. Attention has also been called to the gyroscopic effect upon the bearings, when a vessel is in a seaway or turning; but Mr. Parsons has pointed out that in the case of the "Cobra" at maximum speed and in the worst possible sea, these forces would not amount to more than one-half of the normal weight upon the bearings. In certain types of turbines, notably those of the impulse principle, the erosion of the blades is liable to cause trouble. In the Parsons type, where the steam velocities are comparatively low, the blades do not give any trouble on this score, at least so far as experience has demonstrated at present.

Closely associated with reliability is ease of repair. To some the multitude of small blades may seem somewhat complex, but in reality this is not so. In the case of one accident, where a number of blades were stripped, the turbine was stopped, the débris removed, and the turbine started again and run for the remainder of the day, apparently without appreciable decrease in power. In all, the accident caused a loss of about three hours.

The first commercial vessel to be fitted with Parsons turbines was the "King Edward," built in 1901. Since then this vessel has been run continuously during the summer months and has given entire satisfaction.

No doubt the cylinders of the larger turbines will require considerable attention in design, in order to take care of the expansion. They are apt to distort when heated, especially as the temperature along the cylinder may vary from about 400 deg. F. to 100 deg. F., thus causing a varying expansion radially. This may lead to increased clearance spaces, but immunity from possible stripping may demand a slight sacrifice of efficiency.

We now come to the second and, perhaps, the most important consideration, viz., economy. So far as direct comparison of turbines of different powers working under different conditions is concerned, we are met with the difficulty of being unable to determine the indicated horse power of this type of engine. Where it is possible to perform a brake test, such as in land practice, the economy with respect to brake horse power, or horse power delivered, may readily be determined. By making certain assumptions as to the efficiency of the reciprocating engine and applying these to the turbine, we may obtain a quasi-indicated horse-power.

It should be noticed, however, that this is not a satisfactory method, and, so far as ships are concerned, a better measure of economy would be the amount of water or coal consumed per mile or hour at different speeds. For definite information as to the amount of water consumed, we must refer, in the first place, to experiments upon land installations.

The results of a series of tests* upon a 400-kilowatt and a 1,250-kilowatt machine, built by the Westinghouse-Parsons Company, of Pittsburg, show that the consumption of dry saturated steam per indicated horse-power-hour at full load was about 14.5 pounds; and at 50 per cent and 160 per cent load the consumption was about 17 pounds and 15 pounds respectively. With 190 degrees of superheat, the consumption at full load fell to about 11½ pounds per indicated horse-power hour.

On the assumption of 94 per cent efficiency, these figures would give from 14 pounds to 13 pounds per indicated horse power hour under ordinary working conditions with dry saturated steam. For a good average triple expansion engine under similar conditions, the consumption in all probability would be from 12 pounds to 15 pounds, so that from this point of view the steam consumption of the turbine compares favorably with the best reciprocating engine practice.

It is, however, when we come to use superheated steam that the turbine appears in a more favorable light. The economy due to superheated steam is too well known to need any discussion here, but reference is made to the effect of superheating shown in the above figures.

From the results of tests made upon some Westinghouse-Parsons turbines,† the statement has been made that for every 100 degrees of superheat there is a corresponding decrease of 10 per cent in steam consumption.

No doubt there is a corresponding gain in the reciprocating type of engine, but this fact should be borne in mind, that the mechanical difficulties resulting from the use of highly superheated steam increase rapidly with the degree of superheat. The principal difficulty lies in the proper lubrication of the internal rubbing surfaces, such as valve faces, pistons and cylinders, where high-temperature steam is used.

In the turbine, however, there is no need of any internal lubrication, and high temperatures do not materially affect the working of this type, provided difficulties due to expansion do not occur.

In a similar manner the gain due to the use of higher vacuum may be represented as varying from 3.5 per cent to 4 per cent for each 1 inch, depending upon the load. In marine work, reduced power is generally accompanied by decreased revolutions, and as is generally known the efficiency of the turbine falls off considerably under these circumstances. Although data are somewhat lacking upon this point it seems reasonable to suppose that at, say, half power and half the usual number of revolutions the increase in consumption per horse-power-hour should not exceed from 40 per cent to 50 per cent of the normal amount.

In general, the amount of time at which a vessel is running at reduced speed is exceedingly small, except in special cases, such as war vessels. In these, special means for increasing economy have been devised and will be discussed under the next heading.

From the point of view of economy, therefore, the turbine should show as good results as any other type of engine, especially when its adaptability to the use of superheated steam is taken into consideration.

Before leaving this topic, reference should be made to experiments with exactly similar vessels whose only difference lay in the propelling machinery.

In 1904, the British Admiralty conducted an exhaustive set of trials upon the "Amethyst," a cruiser of 3,000 tons, fitted with Parsons turbines, and three exactly similar vessels fitted with reciprocating engines. A full report‡ appeared in Engineering, from which the following is taken: Originally up to a speed of 14½ knots, but since certain improvements in connection with the auxiliaries, to a speed of 10 knots, the reciprocating engine has the advantage so far as steam and hence coal consumption are concerned; but above this speed the turbine has the advantage. At 18 knots

* Read before the Association of Engineering Societies.

* See paper by F. Hodgkinson, Am. Soc. Mech. Engineers, 1904.

† See paper by I. R. Bibbins, St. Louis Convention of the Am. St. Ry. Assn., October, 1904.

‡ See Engineering, London, November 18, 1904.

the reciprocating engine required 24½ per cent, and at 20 knots 40 per cent more water than the turbine. Although some of this difference might be traced to the boilers, the actual amount cannot be great as the heating surface and grate surface were practically the same in all ships.

In the full-speed trials the advantage of the turbine became more apparent; the maximum speed obtained by the reciprocating engine being 22.1 knots, as against 23.63 by the turbine engined vessel, a gain of 1.53 knots, or 6.9 per cent. This is the more remarkable seeing that the boiler installation is the same in all, and the higher speed in the turbine vessel was obtained with slightly less air pressure in the stokehold.

One other case has occurred where direct comparison between reciprocating and turbine engines has been possible. The Midland Railway Company, of England, in 1904 built four vessels, two of which were fitted with four-cylinder triple-expansion engines and two with turbines. This experiment is all the more interesting seeing that one of the turbine vessels is practically the same in all details as the reciprocating type, while in the other full advantage has been taken of the saving in weight due to the turbine, of putting this extra weight into larger propelling machinery.

The vessels were designed for a speed of 20 knots, and the following figures confirm those previously quoted.

From 14 to 20 knots the turbine vessel shows an advantage in steam consumption; between 19 and 20 knots the decrease in consumption is about 8 per cent in favor of the turbine vessel exactly similar to the reciprocating type, while in the other case, where full advantage was taken of the turbine, this figure amounted to 14 per cent.*

From the speed point of view there was also a corresponding gain, the turbine vessels obtaining fully one knot higher speed. An analysis of the results of a number of actual runs under service conditions shows that for the same speed the saving in coal in favor of the turbine amounts to about 9 per cent; or for the same coal consumption the turbine vessel could be run at a speed of 20.3 knots as against 19.5 knots in the vessel with reciprocating engines.

The Cunard Company is about to carry out a similar set of experiments with two large ocean vessels, the "Caronia" and "Carmania." These vessels are 675 feet long, 72 feet broad, and 52 feet deep, and displace about 30,000 tons. The "Caronia" is already running and developed 22,000 indicated horse-power at 19½ knots speed on trial. The "Carmania has already made several trips and another direct comparison on a large scale will soon be available.

We now come to the third requirement, viz., adaptability to conditions of propulsion. From the previous discussion, and from the number of vessels already equipped with turbines, the question of the general adaptability of this form of engine is beyond argument. There remain, however, certain conditions which need consideration. Compared with reciprocating engines turbines possess the quality of a relatively high speed of revolution, and it is this consideration which effectually bars certain types from marine work entirely, and places a limit upon the application of others. High speed of revolution is necessarily accompanied with small propellers, which in themselves are not so efficient as the larger ones. When we come to large vessels the actual size of the propeller plays an important part in the general handling and working of the vessel. Let us consider the principal types of vessels in the merchant service. These may be divided into the cargo boat of slow speed, the intermediate cargo and passenger with moderate speed, and the purely passenger or high-speed type. In the purely cargo boat not only is the power small relatively to the vessel, but also absolutely. For example, a large ocean freighter of, say, 500 feet in length, and say, 17,000 to 18,000 tons displacement, would not have engines of more than say 3,500 indicated horse-power, or about the same as that estimated for the "King Edward." The diameter of the center propeller in this case was 57 inches, and the two outside ones slightly less; the revolutions being 505 and 755 respectively. Such small propellers are evidently unsuited for the case in point, and, if the speed of revolution were reduced so that a propeller of larger diameter could be employed, the diameter of the turbines would have to be increased, with the result of little, if any, saving in weight and certainly decreased economy over the ordinary type of engine. We are forced, therefore, to this conclusion, that where the machinery installation or power is small relatively to the vessel, there is no advantage in the use of the turbine, but rather the opposite.

In the intermediate and fast passenger types the conditions just discussed do not hold, as in these cases large or fairly large powers are required, which naturally entail the use of large propellers, even though the revolutions be kept the same as in the smaller engines.

The one serious drawback that the turbine possesses is its inability to reverse. Although in most cases, in the merchant marine, an engine is moving ahead for about 99 per cent of its time, yet the condition of reversibility must be met. In all present arrangements a special reversing turbine is fitted, usually at the end of the low pressure, and runs *in vacuo* when the main turbine is running ahead.

The objection is sometimes heard that turbine vessels cannot be stopped as quickly as those of the ordinary type, and to a certain extent this is true with many vessels. The fact should be borne in mind, however, that the time required to bring a vessel to rest depends largely upon the power exerted, and if sufficient backing power be supplied there is no reason why the turbine vessel should not be as handy as the ordinary type. The objection is, however, a real one, for while in the case of the reciprocating engine the full power is always available for backing, in the case of the turbine, full power in the astern direction would mean a large additional weight and the carriage of a useless engine for the greater part of the time.

Certain experiments upon this question have been performed which tend to show that even with moderate backing power the turbine vessel is fairly handy.

Torpedo boat No. 293 of the French navy, 130 feet long, displacement 94.6 tons, brought to rest from a speed of 20 knots in 4½ times her own length, or in 585 feet. Channel steamer "Queen," 323 feet long, brought to rest from a speed of over 19 knots in 2½ times her own length, in 1 minute 7 seconds. Steaming astern, she attained a speed of 13 knots. Channel steamer "Manxman," 330 feet, brought to rest from full speed (about 22½ knots) in 1½ minutes.

In war vessels the conditions as to operation at reduced powers and maneuvering are much more severe than those which obtain in the merchant marine. Except in special cases, a warship is seldom called upon to develop her full power after she has completed her official trials. Here the turbine as ordinarily fitted for full power would prove undesirable from reasons of economy.

One method of overcoming this difficulty was that adopted in the destroyer "Velox," where two small triple-expansion reciprocating engines were connected by detachable couplings to the low-pressure turbines. The steam after passing through these engines was led into the low-pressure turbines and thence to the condenser. This arrangement is undesirable both from an engineering and operative point of view and has since been discarded in favor of the entire turbine installation.

In the "Amethyst" two small cruising turbines are permanently attached to the main low-pressure turbines. At reduced powers the steam first passes through the cruising turbines and then through the main turbines to the condenser, thus giving a large range of expansion. For intermediate powers the steam is admitted first to the intermediate cruising turbine, then to the main high-pressure turbine and so on to the condenser. For full powers the auxiliary cruising turbines are cut out. This arrangement possesses all the flexibility that can be desired, and if reference be made to the steam consumption curves, it will be noticed that these compare favorably with those of the reciprocating engine.

The question of economy at reduced powers is therefore not such a serious matter as one would suppose at first sight; and, in this connection, it is interesting to note that similar arrangements have been made in the vessels of the Russian volunteer fleet: the reciprocating engines in these vessels working as quadruple at ordinary speeds and triple at the higher speeds required on government service.

In connection with the question of weight, there is no doubt that the turbine possesses an advantage over the reciprocating engine. In the case of the Midland Railway boats, referred to above, the reciprocating engines, shaft and propellers weighed 280 tons, on the turbines 195 tons, a difference of 85 tons, or 30 per cent. There was also a saving in hull construction weights of about 30 tons, making a total saving of 115 tons.

	Reciprocating.	Turbine.
Boilers	460	390
Engines	210	160
Shafting and propellers	60	25
Total	730	575
Speed	21.9 Knots	22.3 K.

Even in the foregoing figures full justice is not done to the turbine, when the speed is taken into consideration.

For the same weight of machinery in the case of the "King Edward" the speed of the turbine boat was 20.5 knots, as against 19.7 probable speed, if reciprocating engines had been fitted, or a gain in horse power of about 20 per cent.

In the case of the cruiser "Amethyst," the weight of machinery was practically the same as that of the reciprocating engined ships, viz., 530 tons. The speed of the "Amethyst" was, however, 23.63 knots against 22.1 for the other vessels.

	Reciprocating.	Turbine.
Engines and boilers	537	535
I.H.P.	9,900	(14,000)?
Speed	22.1	23.63

For the same speed and displacement there would be a saving of about 155 tons, or nearly 30 per cent, on the weight of machinery alone. This would also be accompanied by less coal and water, or if these were increased so as to keep the total weights the same, there would be a corresponding increase in radius of action.

With regard to floor space occupied, there is nothing to choose between the reciprocating engine and the turbine. In space taken up in the vertical direction, the turbine has a distinct advantage, although in the merchant marine this may not always be an unmixed blessing on account of the tonnage laws.

The situation may, therefore, be summarized briefly as follows: So far as reliability is concerned, there seems to be no reason why the turbine should be inferior to the reciprocating engine; while from the point of view of economy and speed, the turbine has shown itself in many ways superior. At very low speeds, however, the reciprocating engine is superior in economy of steam, but against this the turbine requires less oil and a slightly less engine-room staff. The turbine in its present state is not suitable for all classes of ships. Where the speed is high or fairly high, that is, in passenger and intermediate types, war vessels and yachts, it may be used to advantage; but in slow cargo vessels where the power is small relatively to the size of ships, and for those vessels which require to be started and stopped at frequent intervals, the turbine is not suitable. From the weight point of view the turbine is certainly superior to the reciprocating engine of the same power, especially in the case of ordinary high-speed vessels. It possesses also the advantage of being perfectly balanced, and hence the vibrations of the vessel may be considerably reduced. From figures available, the cost is slightly in excess in the case of the turbine, but as the speed of the vessel is usually greater, this is more apparent than real. So far as space occupied is concerned, there is little to choose between the two, the turbine having the advantage so far as height is concerned.

In conclusion, it may be interesting to note the number of vessels built and building, in which the turbine in some form, although mostly of the Parsons type, is employed. In the merchant marine there are some forty-three, ranging in size from small yachts to the new Cunard vessels which will have in the neighborhood of 65,000 indicated horse-power. Five naval vessels have been built and twenty-one are building, making a total of some sixty-nine vessels in all.

* See paper by William Gray, Inst. Naval Architects, London, July, 1905.

IMMIGRATION STATISTICS.

During the fiscal year 1,062,054 tourists and aliens passed through the immigration station. Of this number, 935,000 come under the head of alien newcomers who had emigrated to this country, the rest being composed of that conglomerate class which crosses and recrosses the Atlantic in 'tween-deck quarters, some being aliens who had obtained naturalization papers and who had gone abroad to revisit old haunts, some others being of that frugal type which crosses to Europe in steerage or second-cabin quarters, to return as third-class, and as such to come under the supervision of the Immigration Bureau.

Of the total million and odd that passed through Ellis Island during the fiscal year, 609,714 were males. Those under fourteen years old numbered 106,990; those over forty-five, 38,296. Of the entire number, 99,884 had been here before, these being largely the ones who had obtained a competence here and had utilized part of their savings to make trips to their old homes.

Italy furnished the largest proportion of the newcomers, that nation sending 221,696 of its population to this country during the year. Next in point of numbers are the Hebrews, of whom an army of 125,000 arrived, most of these being refugees from Russia. Germany sent 71,916 of her people. The Magyars came next, with 42,000. The rest are classed under the head of miscellaneous.

The total footing shows an increase of 99,075 actual immigrants over the number of aliens who passed through Ellis Island last year. The arriving horde brought, it is estimated, about $19,000,000. For purposes of comparison it may be interesting to note that a former official of the Treasury Department has recently made a computation by which he figures that Americans who visit Europe this year will expend there the enormous sum of $100,000,000. The comparison, of course, must be long drawn out, as the American tourist is one who usually goes abroad with all the consequence that wealth can give, while those who reach this country in steerage quarters are those of the laboring class.

There were 7,877 deportations during the year, of whom 195 were excluded on the proven charge that they were criminals. There has been much talk of anarchists being refused admission, but the records do not show that any one has been barred because of this charge.

The report of the Commissary Department of Ellis Island shows that there has been an average of 6,000 meals per day served to newcomers, which makes the dining room of the immigrant station one of the biggest in the country. In the report attention is called to numerous anonymous letters which had been sent to Washington and to newspapers of this city, alleging that employes of the Landing Bureau were overworked. It is shown that the inspectors worked on an average seven hours a day.

In trials to determine the physiological action of feeble radio-activity carried on by E. S. London, the results of which were published in Archives d'El. Médicale, a specimen consisting of 18 milligrammes of radium, applied to the skin of the forearm for brief intervals of time, was found to produce a reaction after a minimum exposure of 15 seconds duration. Three rabbits were confined in a cage 43 centimeters long, 41 broad, and 31 high. In the middle of the roof of the cage 260 milligrammes of radium bromide were placed. Redness of the ears was observed after sixteen days, and burns soon began to form on the skin of the back. After fourteen months the backs and heads of the animals were denuded of fur and covered with ulcers. The animals had become apathetic and slow in movement, the hind legs were partially paralyzed. Central retinitis was present in the eyes of all three and optic neuritis in one. The sexual instincts were abolished. Post-mortem examination revealed changes and degenerations in the muscles, liver, spleen, kidneys, and generative organs.

THE USE OF ALCOHOL AS A FUEL FOR GAS ENGINES.*

By H. Diederichs.

THE FUEL.

The present article will consider the fuel value and the physical properties of alcohol, and the details of the alcohol engine, wherever they may be different from those of a gasoline or crude oil machine. Further, the efficiency and cost question will be briefly discussed.

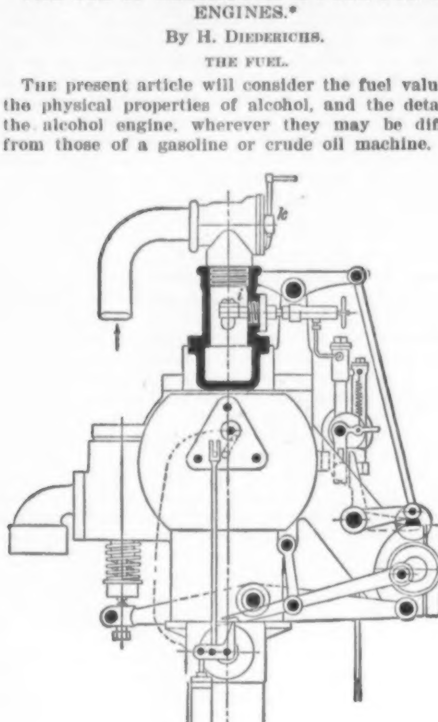


Fig. 1.

Ethyl alcohol, whose chemical formula is C_2H_6O, may be made in various ways but the commercial alcohol of to-day is the result of fermentation, generally of grape sugar, in the final stage. The raw materials are various. Thus, according to Sand† they may be divided into three classes:

1. Those containing starch: Potatoes, with 15 to 24 per cent starch; rye, with 50 to 56 per cent starch; corn, with 60 per cent starch.
2. Those containing sugar: Sugar beet, with 8 to 18 per cent sugar; sugar cane, with 12 to 16 per cent sugar.
3. Those containing alcohol: Wine, with 9 to 16 per cent alcohol.

The method of manufacture, of course, varies with the raw material, but need not be described in detail here. Theoretically, 100 pounds of grape sugar should yield 51 pounds of pure alcohol; in reality the yield is from 1-5 to 1-3 less than this amount.

A second method of producing alcohol, notably that mentioned by Witz in his "Moteurs à Gaz et à Pétrole," is to start with calcium carbide as a raw material. This, by a somewhat complicated process, can be changed from CaC_2 through the stages of C_2H_2 and C_2H_4 to alcohol, C_2H_6O. Barium carbide or strontium carbide can be used in the same way. Witz states that from 1 kilogramme (2.2 pounds) of calcium carbide 0.8 liter (1.69 pints) of alcohol can be obtained; this is equivalent to 0.096 United States gallons of alcohol from 1 pound of carbide. Estimating the price of carbide at 3 cents per pound, which is even now somewhat below the market price, 1 gallon of alcohol would therefore cost, in raw material alone, 31.2 cents, to say nothing of the cost of the chemical operations. The by-products in the case of the calcium carbide do not amount to much. There is consequently little likelihood that the so-called synthetic or mineral alcohol will ever seriously compete with gasoline or kerosene for power, as will be shown later.

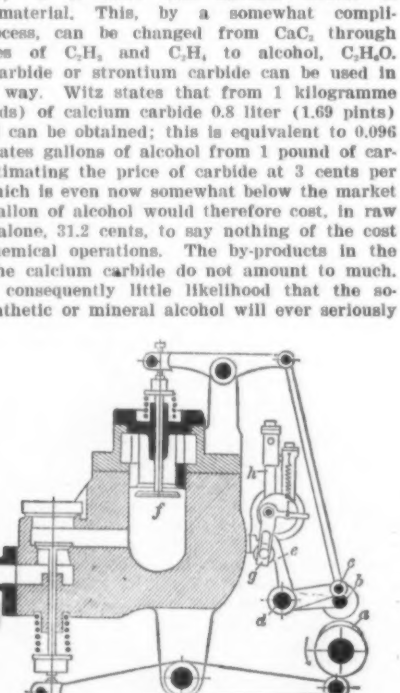


Fig. 2.

The heating value of alcohol cannot be accurately computed from its chemical composition, because nothing definite is known of the arrangement of the atoms entering the composition. We therefore have to depend upon the calorimeter. The figures determined for absolute alcohol by various experimenters are as follows:

	Higher Heating Value, per Pound.	Lower Heating Value, per Pound.
Thompson	13,310 B. T. U.	12,036 B. T. U.
Favre & Silberman	12,913 B. T. U.	11,664 B. T. U.

The value 11,664 B. T. U. is the one most generally used. Absolute alcohol has a specific gravity of 0.7946 at 15 deg. C. (59 deg. F.), so that one gallon of pure alcohol weighs 6.625 pounds, and has a lower heating value of 77,274 B. T. U.

One pound of C_2H_6O contains 0.522 pound carbon, 0.130 pound hydrogen, and 0.348 pound oxygen.

According to this there will be required for the combustion of one pound of absolute or 100 per cent alcohol

$$\frac{(0.522 \times 2.66) + (0.130 \times 8) - 0.348}{0.23} = 9 \text{ pounds of air.}$$

This is the equivalent of 111.5 cubic feet of air at 62 deg. F., per pound of C_2H_6O. Commercial alcohol, however, is never pure, but nearly always contains a certain quantity of water, the admixture being measured according to volume per cent. Thus, 90 per cent alcohol means that the mixture carries 10 per cent by volume of water. The heating value of such alcohol is of course correspondingly reduced from that of 100 per cent alcohol according to the following table, due to Schöttler:

Abs. Alcohol, Volume, per Cent.	Specific Gravity.	Abs. Alcohol, Weight, per Cent.	Lower Heating Value, per Pound, B. T. U.
95	0.805	93.8	10,880
90	0.815	87.7	10,060
85	0.826	81.8	9,360
80	0.836	76.1	8,630
75	0.846	70.5	7,920
70	0.856	65.0	7,200

It is required by law, in countries where alcohol is now used in the industries, to so fix the fuel that it is rendered undrinkable. This process is called "denaturizing" the alcohol. The bill at present before Congress provides for the same thing. The materials used for this purpose differ in the various European countries.

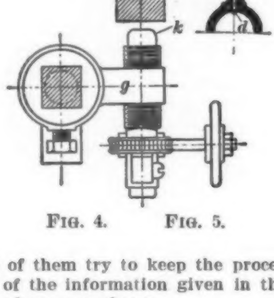


Fig. 4. Fig. 5.

Some of them try to keep the process a secret, hence some of the information given in the following table* is based upon analyses.

Materials Used to Denaturize Ethyl Alcohol.

Country.	Sp. Gr. of Denaturized Alcohol at 15° C.	Methylene (Wood Alcohol) and Its Impurities, per Cent.	Pyridine or Pyridine Bases, per Cent.	Acetone, per Cent.	Benzol, per Cent.	Benzine, per Cent.
France	0.832	7.5	....	2.5	. .	0.5
Germany—						
Denat. alcohol	0.819	1.5	0.5	0.5	....	....
Motor alcohol	0.825	0.75	0.25	0.25	2.0	....
Austria—						
Denat. alcohol	0.835	3.75	0.5	1.25	....	....
Motor alcohol	0.826	0.5	trace.	trace.	2.5	....
Russia	0.836	10.0	0.5	5.0	....	....
Italy—						
Motor alcohol	0.835	6.5	0.65	2.0	1.0	...
Switzerland	0.837	5.0	0.32	2.2	....	....

It will be noted from the table that the material most used for denaturizing ethyl alcohol is wood alcohol. The heating value of the fuel is by the addition of the denaturizing liquid changed but little in most cases.

Benzol, C_6H_6, besides being used for denaturizing, is sometimes used in larger quantities than indicated in the above table for the purpose of increasing the heating value of the fuel mixture per pound. Benzol has a specific gravity of 0.866 and a heating value of 17,190 B. T. U. per pound. A mixture of x per cent by weight of absolute alcohol with y per cent of benzol will therefore have a heating value of

$$[11664\,x + 17190\,y] \text{ B. T. U. per pound.}$$

If the alcohol is not absolute, its proper heating value should be substituted from the table above given. In this way from 10 to 40 per cent of benzol is sometimes employed, thus raising the heating value of the fuel, and at the same time decreasing the specific heat cost, i. e., the cost per heat unit.

There is a second reason why benzol is employed. Under certain circumstances there will be formed acetic acid in the products of combustion of alcohol. This causes rusting of the engine parts. On examination it will be found that this is due to a combustion with insufficient air supply, and the surest way to prevent rusting therefore is to use a good excess of air, and to have a perfect mixture. Under such conditions there will be no danger of corrosion. It is also found that a good addition of benzol acts as an additional safeguard. It should not be forgotten in this connection, however, that the great advantage possessed by alcohol in its odorless exhaust is sacrificed to some extent by the use of benzol.

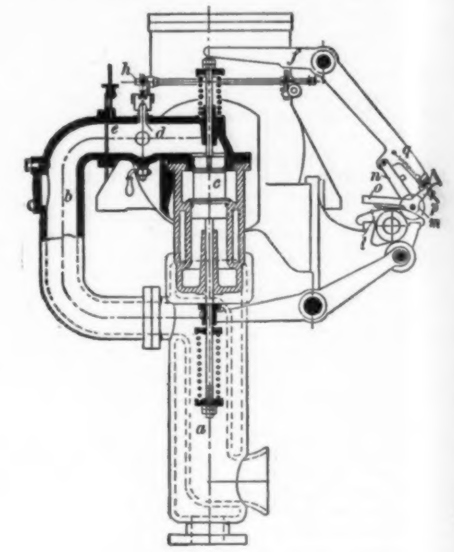


Fig. 3.

THE ENGINE.

Taking up next the mechanical details of the alcohol engine, we find that they do not differ materially from those of the ordinary gasoline engine. As a matter of fact, any gas or gasoline engine can be run on alcohol, if only a means be provided to form the fuel mixture. The first trials with alcohol were made on liquid fuel engines so provided. It was soon discovered, however, that the efficiency of operation of alcohol engines could be materially increased if the compression were increased above that possible for gasoline. Hence this is the main point of difference between gasoline and alcohol engines. The other point is the one above mentioned, i. e., that a different vaporizer or carbureter is required.

There has naturally been very little work done on alcohol engines on this side of the water. In Europe, however, especially in Germany and France, there are to-day many alcohol engines in operation, used mostly in agricultural industries. For this purpose the other advantages possessed by alcohol overbalance the somewhat greater operating costs. One such advantage is the greater safety of alcohol as compared with gasoline, which makes the packing and shipping so much easier, and the conditions imposed by insurance companies much less strict and hence less irksome, to say nothing of the lower cost of insurance. Again, the production of alcohol is not confined to certain localities, as is that of a product like crude oil, gasoline, or kerosene. It may be grown and made almost anywhere, and hence the freight charges to the consumer will in most cases be comparatively smaller than for the crude oil products.

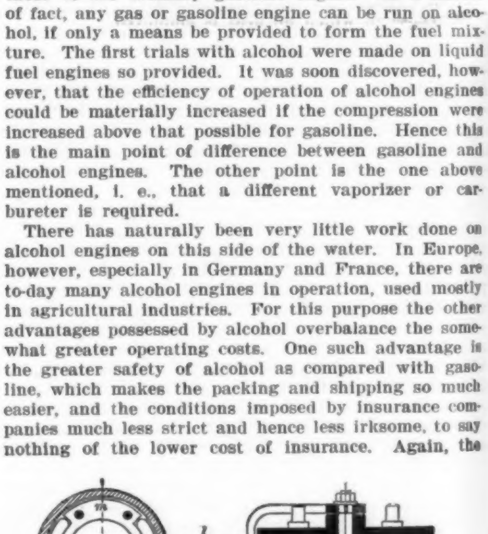


Fig. 6.

It is therefore to Germany that we have to look for

* From International Marine Engineering.

† Sand, Zeitschrift des Vereines deutscher Ingenieure, 1894, p. 933.

* Zeitschrift des Vereines deutscher Ingenieure, June, 1905.

information regarding alcohol engines. The following material is taken mainly from the work of E. Meyer* and of R. Schöttler†, and from the discussions of Güldner‡, Diesel§, and others, published in the Zeitschrift des Vereines deutscher Ingenieure. To all these the writer desires to render his acknowledgment.

Regarding the formation of the fuel mixture with

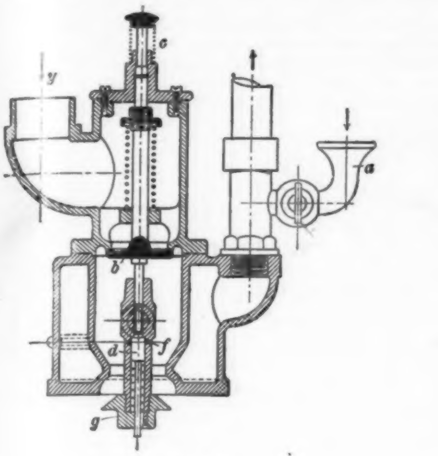


Fig. 7.

alcohol, it is found that it is less volatile than gasoline, but easier to handle than kerosene. In nearly all of the vaporizing devices for alcohol now on the market, the agency of heat, usually the exhaust heat of the waste gases, is used to aid in the formation of the mixture. This scheme has the drawback that no heat is available at the start when the engine is cold, and it is next to impossible to start a cold engine on alcohol. To avoid an open flame for the purpose of heating the vaporizer at the start, which is both dangerous and cumbersome, the engines in most cases are started with gasoline, and when, after a few strokes, enough heat is available, the change is usually made by throwing over a single lever. In tests of ten different engines made by Meyer, it was shown that this change to alcohol could be made in the slowest case in 6 minutes and 40 seconds, the time of the fastest being 55 seconds.

Based on the manner of heating the vaporizer, we can distinguish the following classes:

1. Those in which no heat is employed.
2. Those in which the air is preheated.
3. Those in which the mixture is heated and superheated.

Of the first type is the Deutz, Figs. 1 and 2. When the engine is regulated by the throttling method, and not by the hit and miss system, it has been found that no preheating of air or fuel mixture is required. The reason for this is undoubtedly that in a hit and miss engine, under less than normal load, a succession of misses cools the cylinder down so far as to throw down some of the alcohol vapor on the next explosion, unless it is superheated. The Deutz engine is governed by throttling. The inlet valve, *f*, is actuated through the levers shown, by the cam, *a*, which is of taper form and under the control of the governor. Upon the position of *a* depends the length of time the valve, *f*, is open. Through the bell crank, *c d e*, the cam also acts upon the plunger of the fuel pump, *h*, operating in such a way as to cause suction during the first part of the cam movement, and pumping of the liquid during the second. Thus the fuel is injected during the second half of the suction stroke only, insuring a rich mixture around the igniter. The alcohol is forced through the sprayer or atomizer, *i*, Fig. 1, into the current of air which enters through

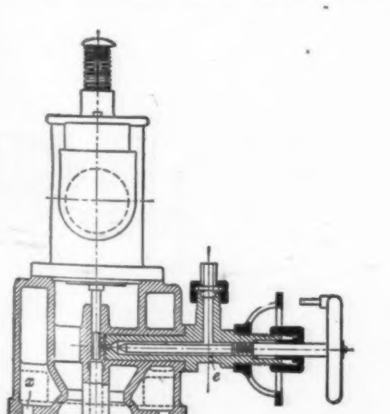


Fig. 8.

the valve, *k*. Thus no preheating whatever is done, but the atomizing is thorough; and the ports into the cylinder are as direct and short as possible, hence no vapor is thrown down.

* E. Meyer, Zeitschrift d. V. d. I., 1903, pp. 513, 600, 632, 669.
† R. Schöttler, Zeitschrift d. V. d. I., 1902, pp. 1157, 1223.
‡ H. Güldner, Zeitschrift d. V. d. I., 1902, p. 628.
§ R. Diesel, Zeitschrift d. V. d. I., 1903, p. 1366.

The Altman vaporizer, Fig. 3, is of the second class. The air pipe, *a*—*b*, is surrounded at its lower end by the exhaust pipe; the air is thus preheated by the exhaust gases. A regulating valve for the air is placed at *e*. This, when drawn upward, decreases the amount of air passing, but always makes the air current strike through the upper part of the pipe, in this manner directing it always against the fuel nozzle, *d*. The inlet valve, *c*, is operated by the lever, *f*, actuated by the cam, *l*, through the pendulum hit and miss governor, *o m p*. This valve lever, *f*, at the same time opens the fuel valve, *d*, through the reach rod shown and the finger, *h i*, Fig. 5. How this is done is shown in Fig. 4. The lever, *f*, on being depressed, forces down the point of the screw, *k*, thereby turning the reach rod about its axis, which depresses the point, *i*, Fig. 5, opening the valve *d*. The amount of opening depends upon the position of the screw, *k*, and this can be very finely adjusted by the worm and wheel arrangement shown. In this vaporizer the fuel supply is atomized partly by the current of air, and is afterward vaporized by the heat of the preheated air.

The following three vaporizers are of the third class. Fig. 6 shows the Swiderski-Longuemarre. Here also the exhaust gases are used for heating. They pass through the annular chamber, *a*, and their action is aided by the radiating webs, *b*—*b*. The float, *d*, maintains a constant level in the supply chamber. From this chamber the flow of alcohol is regulated by the needle valve, *f*. The liquid flows into the space, *g*, and overflows through a number of small openings, *h*—*h*. Air entering through *i* is made to pass partly outside, partly inside the concentric spaces created by the sleeve, *k*. The amount of air passing outside is regulated by the openings, *n*—*n*, which are controlled by the lever, *l*. The air currents passing upward carry along with them some of the liquid, the mixture being heated by the exhaust gases in *a*. The perforated plate, *o*, tends to aid in forming a uniform mixture.

The vaporizer of the Dresdener Gasmotorenfabrik is

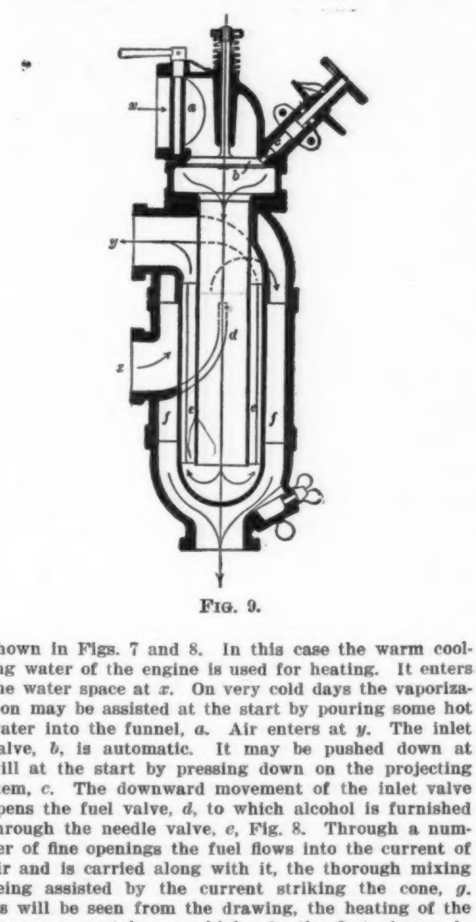


Fig. 9.

shown in Figs. 7 and 8. In this case the warm cooling water of the engine is used for heating. It enters the water space at *x*. On very cold days the vaporization may be assisted at the start by pouring some hot water into the funnel, *a*. Air enters at *y*. The inlet valve, *b*, is automatic. It may be pushed down at will at the start by pressing down on the projecting stem, *c*. The downward movement of the inlet valve opens the fuel valve, *d*, to which alcohol is furnished through the needle valve, *e*, Fig. 8. Through a number of fine openings the fuel flows into the current of air and is carried along with it, the thorough mixing being assisted by the current striking the cone, *g*. As will be seen from the drawing, the heating of the charge can not be very high. In the first place only the comparatively cool jacket water of the engine is used, and secondly the mixture itself is not in the heated chamber for any length of time.

In contradistinction to the Dresden vaporizer, the Dürr, Fig. 9, produces a highly heated mixture. Air enters at *x* and its amount is regulated by the throttle valve, *a*. The inlet valve, *b*, is automatic. Alcohol is supplied through the needle valve, *c*, as shown, so that when *b* is closed no flow of alcohol takes place. The current of air charged with alcohol particles passes down through *d*, up the annular space, *e*, and out at *y* to the cylinder. The exhaust gases enter at *z*, and by means of baffle plates are made to take the course shown by the arrows, through the space *f*. Further, the space *e* is filled with a large number of metal spirals, which connect the outside wall of *e* with its inside wall, thus furnishing a large heated surface to the passage of the charge, and facilitating the transfer of heat from the space *f* to the space *d*. Every possible way is therefore made use of to apply the heat of the exhaust gases, and this vaporizer therefore furnishes a mixture more highly superheated than that of the others.

Finally, Fig. 10 shows what may be called a double float carbureter, which is the form that alcohol vaporizers are likely to take. This is used on the Marienfelde machines. Assume that the chamber *a* is used for gasoline, *b* for alcohol. The needle supply valves can be held closed by the springs *c* and *d*, as shown.

On starting with gasoline, the chamber *a* is used. Spring *c* is pushed aside so that fuel can enter, being kept at constant level by the float. The valve, *g*, is so set that the path is open for the air from *h* past the gasoline nozzle, *e*, through *g* into the cylinder. At every suction stroke the inrushing air is then charged with gasoline issuing in a small jet from *e*. If it is

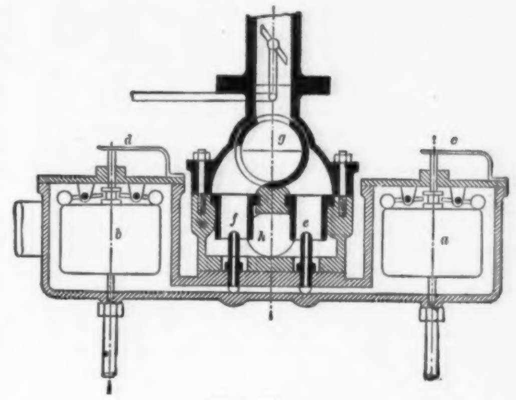


Fig. 10.

desired to change to alcohol, spring *c* is pushed into place, spring *d* is pushed aside, and valve *g* is thrown over into the position shown in Fig. 10, all the work of a moment. The air supply to this vaporizer is preheated.

It is quite evident from an examination of the vaporizer above described that the final temperature of the mixture is different in the different devices. Upon this temperature, however, depends in a great measure the only other point of difference between gasoline and alcohol engines, i. e., the amount of compression. All other things being the same, that fuel mixture entering the cylinder at the highest temperature will soonest give rise to preignition, or at least to pounding, under an increase in compression. High temperature of charge also affects engine capacity unfavorably. It therefore becomes important to determine approximately the *lowest* practical temperature of vaporization, and the heat necessary.

Of course the amount of heat required depends upon the amount of alcohol (and its purity) per pound or cubic foot of air. Assuming that 90 volume per cent alcohol is used, the theoretical amount of air required for perfect combustion is 7.8 pounds. Assuming that an excess of 50 per cent of air is used, which is a desirable allowance, 1 pound of 90 per cent alcohol would require in round numbers 11.7 pounds of air. With the air temperature at 60 deg. F., and the atmospheric pressure 14.7 pounds per square inch, this amounts to 0.0065 pound of 90 per cent alcohol per cubic foot of dry air.

Ninety per cent (volume) alcohol is equivalent to 87.7 (weight) per cent, so that 1 pound of air will carry, according to the above assumed ratio of mixture,

$$0.877 \times \frac{1}{11.7} = 0.075 \text{ pound of absolute alcohol,}$$

$$\text{and } 0.123 \times \frac{1}{11.7} = 0.010 \text{ pound of water.}$$

To compute the air temperature required so that it

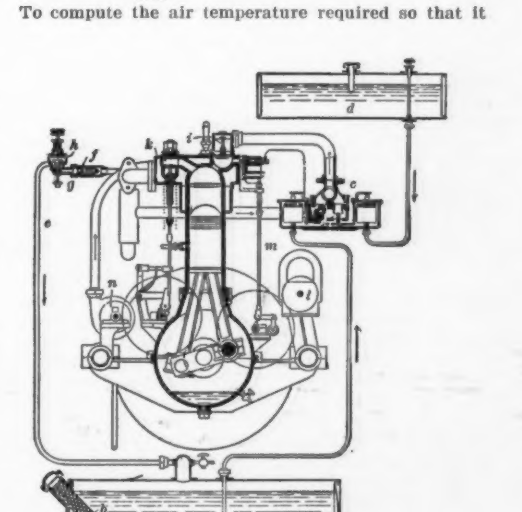


Fig. 11.

may take up the above quantities of alcohol and water vapor, we must know the relation between the temperature and the degree of saturation. Meyer in his computations used the data contained in the Physikalisch-Chemische Tabellen of Landoldt & Börnstein. For our purpose the figures of the table have been transposed into English units.

Temperature, Deg. F.	Vapor Tension, Inches Mercury.		One Pound of Air Contains, in Saturated Condition, in Pounds			
			At 28.96 Inches, Hg Press.		At 28.06 Inches, Hg Press.	
	Alcohol Vapor.	Water Vapor.	Alcohol Vapor.	Water Vapor.	Alcohol Vapor.	Water Vapor.
50	0.960	0.359	0.055	0.008	0.061	0.009
59	1.283	0 5 0	0.075	0.011	0.084	0.013
68	1.733	0.687	0.104	0.016	0.117	0.018
77	2.335	0.925	0.144	0.022	0.162	0.025
86	3.080	1.240	0.200	0.031	0.227	0.036
104	5 270	2.163	0.390	0.063	0 450	0 072
122	8.000	3.620	0 827	0.135	1.062	0.164

In the ordinary case the air drawn into the vaporizer is not dry, but contains a certain quantity of water. Assume that the air is at a temperature of 59 deg. and just saturated. At a pressure of 26.05 inches of mercury this would correspond to 0.013 pound of water per pound of air in its initial condition. Now in the case of the average mixture above computed, the temperature of vaporization must be high enough to vaporize an additional 0.010 pound of water, making the total 0.023 pound that the air must contain per pound. It is seen from the table that a temperature of 77 is quite sufficient to do this. It is also seen that at this temperature the air may take up 0.162 pound of absolute alcohol, while the quantity in the above mixture is only 0.075 pound per pound of mixture. At a temperature of 77 deg. the mixture ready for the cylinder may therefore contain the alcohol vapor in a state of some superheat. If therefore the temperature of the walls with which the mixture comes in contact is not less than 77 deg., no fear of condensation of alcohol vapor need be entertained. In this connection a statement in the Engineering Record is of interest. It is there claimed that the consumption of alcohol with the jacket water leaving at 60 deg. F. is 100 per cent higher than with jacket water leaving near 212 deg., i. e., with cooling by vaporization. In the light of the above facts, some such increase in the consumption is quite possible.

In order to convert the liquid alcohol into vapor, a certain quantity of heat is required. According to Regnault, this amount is, for the various temperatures given, and computed above 32 deg. F., as follows:

At 32 deg. F........ 425.7 B. T. U. per pound.
68 deg. F........ 453.6 B. T. U. per pound.
122 deg. F........ 475.2 B. T. U. per pound.
212 deg. F........ 481.1 B. T. U. per pound.

The specific heat of liquid alcohol is close to 0.6, so that in order to convert the quantity of 90 volume per cent alcohol contained in the assumed mixture to alcohol vapor at 77 deg. F., would require approximately, assuming the liquid alcohol at 60 deg. F, 0.075 × [458 − (28 × 0.6)] + [0.010 × 1100] = 44.1 B. T. U. where 1,100 B. T. U. is assumed as the heat of vaporization of water under the existing conditions.

Now the heating value of 90 volume per cent alcohol has been shown to be 10,080 B. T. U. per pound, so that the heating value on one pound of our assumed mixture will be 0.075 × 10,080 = 756 B. T. U. The heat of vaporization required is therefore $\frac{44.1}{756} = 5.8$ per cent of the heating value of the fuel. It can be shown that the amount of heat is easily obtainable from the exhaust gases. It can also be shown that the problem may be solved by preheating the air only, for, assuming that the specific heat of air at constant pressure is 0.238, we would have to preheat the air for the assumed mixture to $\frac{44.1}{.238} + 77 = 262$ deg. F., which is easily possible.

If, on the other hand, not the air but the mixture is heated, then the walls need to have a temperature only sufficiently higher than 77 deg. to transfer the required amount of heat for vaporization to the mixture in the time available. To furnish more heat than this is harmful, if anything, for it affects unfavorably both the possible degree of compression and the capacity of the machine. The cooler the mixture after formation and vaporization, the better.

This point was strikingly brought out in the tests made by E. Meyer in 1902. As above explained, the Deutz vaporizer uses no heat either for the air or the mixture. The walls of the chamber near the atomizer felt cold to the touch, and during the tests were covered with water vapor. This shows conclusively that the alcohol in the mixture could not have been completely vaporized. The ports from the atomizer to the cylinder are in the case of the Deutz engine very direct and short, so that probably no serious separation of liquid occurs. Once in the cylinder the vaporization is quickly effected, for the cylinder walls are hot, the method of cooling used being that by vaporization. In any case, however, the final mixture is comparatively cool, and the degree of possible compression correspondingly high, the ratio of compression during the tests being 8.9.

The Dürr vaporizer, on the other hand, gives the most highly diffused and highly heated mixture. A highly diffused, i. e., a perfect mixture, of course affects the alcohol consumption favorably, and for that reason the consumption of the Dürr engine per horse-power-hour was not much greater than that of the Deutz. But the high temperature of the mixture compelled the use of a lower degree of compression, the ratio used being 6.68, and even at this point the explosions in the Dürr engines were sharper than those in the Deutz. If the Dürr machine had been able to use the same degree of compression as the Deutz, Meyer figures that its fuel consumption would have been lower than that of the latter.

It may be asked why a higher compression should show a better fuel consumption per horse-power-hour, i.e., a better thermal efficiency. It can be shown on theoretical grounds that the thermal efficiency of an Otto cycle can be expressed by

$$E_t = 1 - \frac{1}{r^{n-1}}$$

where r = ratio of compression =

$$\text{ratio of } \frac{\text{total cylinder volume}}{\text{clearance volume}}$$

$$n = \frac{C_p}{C_v} =$$

$$\text{ratio } \frac{\text{specific heat of charge at constant pressure}}{\text{specific heat of charge at constant volume}}$$

Evidently E_t is the greater, the greater the value of r, i. e., the smaller the clearance volume, and hence the higher the compression. And it is found that this theoretical formula is borne out in practice.

The best results so far attained in practice have been with a compression pressure of about 200 pounds. The average compression pressure for good results may be taken at 180 pounds. The corresponding maximum explosion pressure is about 450 pounds.

With the exception of the carbureter and the compression, the design of the alcohol motor does not differ from that of a gasoline machine, as is shown by Fig. 11, which represents a two-cylinder launch engine built by Marienfelde. Alcohol is contained in the vessel, *a*, which is filled through the strainer, *b*. The tank, *a*, is kept under a certain definite pressure by means of the exhaust gases, which forces the alcohol into the left hand float chamber of the vaporizer, *c*. Part of the exhaust gases pass through the strainer *f*, the check valve, *h*, and the pipe, *e*, to the fuel tank. *g* is a safety valve, so that by means of this and the check valve, *h*, a constant pressure is maintained on the liquid in the tank. The inlet valve, *i*, is automatic, while exhaust valve, *k*, is mechanically operated. The fresh air passes through a heater surrounding the exhaust pipe and is thus preheated on its way to the vaporizer. The volume of these preheaters is made from 0.12 to 0.15 of the stroke volume. Ignition is produced by means of the electro-magnetic apparatus *l*, *m* being the make and break gear. Regulation is effected by the hit and miss system. *n* is a small rotary pump, driven as shown, to furnish circulating water for the jacket. The supply of gasoline required to start the machine is kept in a tank *d*, at higher level, so that the fuel is supplied to the right-hand float chamber by gravity. The operation of the vaporizer was explained under Fig. 10.

The following table of dimensions of Marienfelde engines gives some idea of the size of the machines:

Maximum Brake Horse-Power.	R. P. M.	Cylinder Diameter, Inches.	Stroke, Inches.
8 0	220	6.70	11.80
13.9	280	7.90	14.20
21.0	292	9.85	15.75
24.5	270	11 00	15.75
30.0	200	13.80	15.75

EFFICIENCY.

There remains to be considered the efficiency of the alcohol engine and the cost of operation.

Again, next to nothing has been published in this country regarding these points, and we are compelled to turn to other sources. The most extensive testing work has been done by E. Meyer in 1902, for the German Agricultural Society. While the results there obtained were uniformly good, they have been bettered since then, mainly through a further increase in compression. The cost of operation is of course intimately related to the efficiency, and the two will therefore be considered together.

Regarding the specific heat costs of gasoline, kerosene and alcohol, the price of gasoline may be assumed at an average of 15 cents per gallon, that of kerosene at 13 cents. The price of denaturized alcohol is of course still undetermined as far as this country is concerned. In Germany 90 volume per cent alcohol was sold at 15 pfennige per kilogramme in 1902. This is equivalent to about 11.5 cents per gallon. In 1905, however, the price of alcohol was raised to 25 marks per 100 kilogrammes, i. e., to 19 cents per gallon, by the alcohol trust. Regarding the United States, the only reference the writer has been able to find is contained in the Iron Age, March 15, 1905. At a hearing of the Ways and Means Committee, Mr. Kline, representing the Philadelphia Trades League, brought out the following facts, referring to a distillery located in Illinois:

"The cost of production has fallen as low as 5.2 cents per proof gallon, equal to 9.77 cents per wine gallon testing 94 per cent, or 9.36 cents per wine gallon testing 90 per cent.

"The average cost per proof gallon during the entire period of 10 years was 10.78 cents, equal to 20.26 cents per wine gallon, 94 per cent, or 19.4 cents per wine gallon, testing 90 per cent."

"The average cost of corn during the entire period of ten years covered by these records was 42.36 cents per bushel, and the average yield from each bushel was 4.76 proof gallons."

It was further mentioned that alcohol, to be used for beverage purposes, or for use in manufacturing perfumery, flavoring extracts, etc., can be made from merchantable grain only. For the production of denaturized alcohol, however, inferior materials could be employed, thus cheapening production.

In view of the above facts it seems improbable that alcohol testing 90 per cent, from merchantable raw material, will ever be sold for much less than 20 cents a gallon. But assuming that the use of inferior raw materials may eventually bring its cost down to 15 cents per gallon, the specific heat costs of the liquid fuels mentioned would be as per table:

Fuel.	Heating Value, per Pound, B. T. U.	Cost per Gallon, Cents.	Cost per Pound, Cents.	Specific Gravity.	Cost of 10,000 B. T. U., Cents.
Gasoline..	19,000	15.0	2.57	0.710	1.35
Kerosene..........	18,500	13.0	1.88	0.800	1 02
Alcohol, 90 per ct..	10,080	15.0	2.21	0.815	2.19

It is seen at once that alcohol is saddled at the outset with a very serious handicap in the way of greater specific heat cost, as compared with either gasoline or kerosene. To be on a par, therefore, regarding cost of operation, the thermal efficiency of the alcohol engine would have to be $\frac{2.19}{1.35} = 1.62$ times greater than that of gasoline, and $\frac{2.19}{1.02} = 2.15$ times greater than that of kerosene, everything else in the way of engine losses being the same. It remains to be seen how far this has been realized in practice.

In 1903 Diesel found the best figures for the thermal brake efficiencies of gasoline and kerosene engines so far attained to be 20.5 per cent for gasoline and 17.6 per cent for kerosene. This corresponds to a consumption of 0.654 pound of gasoline and 0.727 pound of kerosene per brake horse-power, hour. Banki, with his water injection principle, had reached as high as 27.5 per cent thermal brake efficiency, equivalent to 0.487 pound of gasoline per brake horse-power-hour, but this is a special case. Allowing for some further improvement in gasoline and kerosene engines since 1903, we will assume the best thermal brake efficiency for gasoline 23 per cent, and for kerosene 18 per cent.

The best figure obtained by Meyer in the competitive tests of 10 alcohol engines in 1902 was 365 grammes of 90 per cent alcohol per brake horse-power-hour for the Deutz engine. This corresponds to 0.803 pound of alcohol per brake horse-power-hour and a thermal efficiency of 31.7 per cent. The end compression in this case was about 190 pounds, the explosion pressures exceeded 450 pounds per square inch. It is possible to increase this high efficiency by the use of still higher degrees of compression, but it is questionable whether the use of such high compressions is advisable in average practice. The maintenance and care of the machine become more and more difficult, and it becomes very sensitive to improper setting of the fuel supply valve, pounding and knocking and otherwise unsteady running occurring very easily.

The use of benzol-alcohol mixtures has already been mentioned. The cost of benzol will probably not be very far different from that of denaturized alcohol, but on account of its greater heating value, its specific heat cost is less. The use of a 15 per cent benzol-85-per-cent alcohol mixture has shown in Meyer's tests about the same thermal efficiency as that of alcohol alone. Hence the cost of operation with these benzol mixtures may be slightly less than that for alcohol. In spite of this fact, the use of much benzol is not advisable, because it fouls the engine after a while, making cleaning necessary from time to time.

The above economy and cost figures are collaborated in the following table:

Fuel.	Cost for 10,000 B. T. U., Cents.	Best Consumption of Fuel per B. H. P. Hr. Pound.	Best Thermal Brake, Efficiency, per Cent.	B. T. U. per B. H. P. Hr.	Fuel Cost per B. H. P. Hour, Cents.
Gasoline	1.35	0.580	23.0	11,000	1.485
Kerosene......	1.02	0 725	18.0	14,140	1.442
Alcohol, 90 per ct..	2.19	.0.803	31.7	8,080	1.758

It appears therefore that at the present time, with 90 per cent alcohol at 15 cents per gallon, the operation with alcohol would cost about 19 per cent more than with gasoline, and about 22 per cent more than with kerosene, the prices for the latter being as assumed above. It is to be hoped that this margin can be overcome, either by perfecting the machine, or by decreasing the cost of the fuel. On the basis of the above computations, 90 per cent alcohol, for instance, would have to cost 12 cents a gallon, to be on a par with gasoline. The advantage of gasoline with regard to fuel cost, however, is even now not so great but that it is largely overbalanced by the already mentioned

advantages of the alcohol machine, and that is the real reason why the latter has found such extended application in some European countries, in spite of its slightly greater operating cost.

[Concluded from Supplement No. 1595, page 25551.]

SAND FOR MORTAR AND CONCRETE.*

By Sanford E. Thompson.

COARSE VS. FINE SAND FOR MORTAR.

Compressive Strength and Elementary Volumetric Composition of 2-inch Cubes of Portland Cement and Bank Sand.

Sand.	Proportions by Weight.	Proportions by Volume (Nominal).	Elementary Volumes. Cement. c.	Elementary Volumes. Sand. s.	Density. c + s	$\left(\frac{c}{1-s}\right)^2$	Actual Average Compressive Strength, Age Seven Days, Lbs. per Square Inch.	Estimated Compressive Strength at Six Months, K = 28,000. Lbs. per Square Inch.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
No. 1 Coarse,	1:2.64	1 : 3	0.171	0.518	0.689	0.126	715	3,530
No. 2 Fine,	1:2.64	1 : 3	0.154	0.466	0.620	0.083	405	2,320
No. 3 Very Fine,	1:2.64	1 : 3	0.149	0.451	0.600	0.074	330	2,070

Note.—Quantity in column 7 is from Feret's formula,

$$P = K\left(\frac{c}{1-s}\right)^2$$

in which K is a constant varying with the age of the specimen and the quality of the cement. Relative strengths of similar mortars are in direct proportion to this quantity, and by means of it the compressive strength in column 9 is calculated, assuming an average value for K of 28,000.†

The cubes were made too recently to permit long time tests, but by means of the density tests it is possible not only to compare different sands, but by calculation to closely approximate the actual strength of the mortars. Thus the compressive strength at the age of 6 months, as estimated by Feret's formula, should be approximately 3,530 pounds per square inch for the mortar of coarse sand, 2,320 for the mortar of fine sand, and 2,070 pounds per square inch for the mortar of very fine sand.

The method of making the 2-inch cubes may be of interest, as I do not know of its having been used before for test specimens, although it is in commercial operation for casting artificial stone. I employed the process of sand molding. Wood patterns were first made the size of the cubes required, and molds were formed in fine molding sand as for iron castings. The mortar was mixed to wet consistency in a small laboratory mixer, and poured into the molds, the sand absorbing the surplus water. After remaining in the moist sand for 24 hours, the cubes were removed and placed in water until tested. One of the objects of this method of procedure was to eliminate the variations occasioned by different percentages of water and different degrees of compacting in the ordinary method of brass molds. I have not made sufficient tests to even suggest this process for general use in testing cement, although I have employed it for making large mortar blocks for compression tests with extremely satisfactory and uniform results.

Until recently I have been of the opinion that the density of a mortar was also an exact indication of its water-tightness. Recent tests, however, have led me to question the direct relation between the two qualities. The permeability tests in the present series are not yet far enough advanced to draw positive conclusions, but they indicate a marked difference between the laws of strength and permeability. Concrete specimens were mixed in proportion 1:3:6 by volume, based on 100 pounds of cement per cubic foot, and using gravel for the coarse aggregate. For the fine aggregate, No. 1 coarse sand and No. 3 very fine sand, and mixtures of these two, were used in different specimens. The results showed the concrete with coarse sand to pass considerably more water at the age of 14 days than the concrete made with very fine sand, although the strength of the mortar of coarse sand was more than double that of the fine sand mortar. The flow through the specimens with mixed sands was not very different from the flow through the one with all fine sand.

The results indicated by the tests are that a certain percentage of fine sand is absolutely essential for water-tightness in a mixture as lean as 1:3:6, and after this percentage is reached (in the case of our tests one-sixth of the coarse sand was replaced by the very fine No. 3 sand), there is not very much change in the flow through the specimens by the further increase in quantity of fine sand, or even by the entire substitution of fine sand for the coarse. With proportions 1:2:4 there appears to be such an excess of cement that no additional fine sand is needed. Comparative tests of two specimens of a series made for Mr. Bertram Brewer, city engineer of the city of Waltham, Mass., which city is contemplating the construction of a concrete standpipe, showed scarcely any difference between a bank sand of the nature of No. 1 and the same sand mixed with one-third part of very fine material.

A point of interest which may be noted in connection with these and other similar tests is the fact that the finer sands require a larger percentage of water than coarse sands to produce the same consistency of mortar, the required percentage varying, in fact, with the fineness of the sand. Thus in the density tests, to obtain a soft mortar of uniform consistency in each case, it was necessary to use 15 per cent of water to the weight of cement plus the coarse sand, 21 per cent for the cement fine sand, and 24 per cent for the cement and very fine sand. In the permeability blocks, 7 per cent of water to the total weight of dry material was used in the specimen with coarse sand, this corresponding to 20 per cent of the weight of the cement plus sand, which is a better way of expressing the quantity of water in concrete, while the concrete with the very fine sand required 8 per cent of water to weight of total dry materials, or 24 per cent to weight of cement plus sand to attain the same consistency as the other. The concretes with mixed sands required percentages of water intermediate between these two.

The results thus far have dealt only with natural sand and mixtures of natural sands. Our knowledge of the effect of fine and coarse sand is now beginning to be applied to artificially screening sand into two or three sizes and then mixing them in proportions determined by theory and experiment. Bank sand, or artificial sand containing moisture, must be dried before separating the fine sand particles, but even this expense is not prohibitive in a factory manufacturing concrete blocks or even upon a large structural job, when, as a consequence, the proportions of the concrete may be made leaner and a large saving effected in the proportion of the cement.

For concrete under water pressure I have found by experiment a small percentage of hydrated lime or of slaked lime putty to appreciably increase the water-tightness. Puzzolan cement also has been mixed with Portland cement and used in marine construction to produce a lean impermeable mortar. Several patented compounds are now upon the market, some of which may eventually prove valuable for increasing water-tightness.

The question frequently is asked as to the best composition of sand for concrete. As already indicated, there can be framed no general requirements suited to all conditions. In the case of a small job it is usually unnecessary to restrict the contractor to definite size, because it will be cheaper to use rich proportions than to incur the expense of careful grading.

For mortar sand, Mr. Feret's rule that the coarse grains should be double the fine grains, including the cement, forms a guide as to the best grading. For the strongest mortar, such a rule would require for 1:2 proportions no sand grains passing No. 40 sieve; for 1:3 mortar, 11 per cent of the sand grains passing this sieve, and for 1:4 mortar, 17 per cent. Sand for concrete, I find, requires more fine material than mortar sand, and tests indicate that the best percentages passing a No. 40 sieve may range from about 18 per cent for a 1:2:4 concrete up to 27 per cent for a 1:4:8 concrete. For water-tight concrete even a larger percentage of fine grains appears to be beneficial. As regards dust, that is, the mineral matter passing a No. 200 sieve, good results are attained in rich mortar and concrete with no sand grains finer than this, while for lean mixtures, say, those in which the proportions of cement to sand are 1:4, as high as 10 per cent may be beneficial, and a larger per cent may be used without detriment. While it is impracticable to limit fineness in practice to the exact percentages suggested, they will serve as a guide for comparison and selection.

I cannot well close this paper without touching more definitely upon the general requirements in proportioning sand for concrete. I have already referred to the sizes of sand which from tests thus far made appear to produce the best results. Much finer sands can be used with safety, in fact, if a good coarse sand is not available, almost any size of sand may be used if a sufficient proportion of cement is added, provided it is positively proved by tests using all the materials in the adopted proportions and consistency, that the mortar or concrete sets up and hardens properly. One notable exception to this rule is in the case of concrete laid in sea water, where tests have shown very conclusively that fine sand must never be used.

If fine sand must be adopted for concrete, a smaller proportion of it may be used with reference to the stone of the concrete than with coarse sand, because the finer sand makes a larger bulk of mortar, and the small grains fit more readily between the stones of the coarse aggregate. In the blocks made for the permeability tests described, the 1:3:6 concrete with the coarse No. 1 sand contained only a slight excess of mortar, not much more than was absolutely necessary to completely fill the voids, while the specimen mixed in the same proportions by dry weight with the very fine No. 3 sand had a noticeable excess of mortar, so much as to actually increase the bulk of concrete nearly 8 per cent. This excess came to the surface, although the concrete, which was mixed wet, was rammed scarcely at all. In practice this principle has resulted in requiring proportions with as little sand as in a 1:2:6 mix if the sand is fine, whereas 1:3:6 would have been necessary with a coarse, gravelly sand.

From these somewhat general observations and the results of tests we may summarize the following more important guides to selection of sand:

Coarse sand is always best for a rich mortar; for a lean mortar a small admixture of fine sand with the coarse is beneficial; water-tight concrete appears to require a larger percentage of fine grains than is necessary for maximum strength; if very fine sand must be used for mortar or concrete, it must be excessively rich in cement, and the sand must be tested for setting qualities; if the sand is fine, a smaller quantity may be used in concrete in proportion to the stone; to choose between two sands, make each into a mortar with cement in the required proportions, and for maximum strength, select the one producing a smooth mortar having the smallest volume.

* Read before the quarterly meeting of the Association of American Portland Cement Manufacturers.

† For further discussion see Taylor & Thompson's "Concrete, Plain and Reinforced," pp. 134 to 151.

CONTEMPORARY ELECTRICAL SCIENCE.*

N-ray Photographs.—C. Gutton has investigated the alleged effect of N-rays upon a Hertzian oscillator by means of photographic records. Blondlot maintained that when N-rays fall upon the spark in the primary circuit, the brightness of the secondary spark decreases. This decrease is very difficult to observe on account of the general unsteadiness of the spark. The difficulty was overcome by the author by using brass terminals, which, being more volatile than platinum, gave a steadier spark, and which also, on account of the zinc they contain, are rich in photographic rays. The N-rays were derived from a Nernst lamp surrounded by sheet-iron, and were filtered through wood, paper, and aluminium. The photographs show the effect described by Blondlot quite clearly.—C. Gutton, Comptes Rendus, January 15, 1906.

N-rays.—Prof. Mascart has, in conjunction with Blondlot, Virtz, and Gutton, repeated Blondlot's experiment on the refraction of N-rays by an aluminium prism. The "spectrum" shows a series of maxima, and each of the observers located these by means of a sulphide screen and a dividing machine, and the readings were noted independently by another observer. They were taken in two directions, both going and returning. The consistency between the readings was found to vary with the training of the observer, that of Blondlot being greatest, his maximum error being less than 0.5 per cent. The other observers' errors sometimes amounted to 1 per cent, but they were never sufficient to confuse successive maxima. The mean deviation was 30 deg., and readings were taken to within 2 min.—Mascart, Comptes Rendus, January 15, 1906.

Double Range Portable Electroscope.—C. T. R. Wilson has designed a gold leaf electroscope which reads from +5 to —5 volts and also from 95 to 105 volts, and, therefore, allows of leakage observations both at high and at low potentials. The gold leaf is suspended inside an insulated brass sphere charged to a positive potential of 50 volts. When the leaf is earthed, it differs in potential by 50 volts from the sphere, and is deflected away from its vertical support. A small positive potential makes it fall, and a small negative potential makes it rise. On increasing its positive potential it gradually falls to a minimum deflection, which it reaches at 50 volts. On further raising the potential of the inner coating of the small Leyden jar with which the gold leaf is connected, the latter rises again, and reaches at 100 volts the same deflection as it had at zero potential. The scale will then be the same, only reversed. The gold leaf used is 1.1 centimeter long and 0.2 millimeter wide, giving a deflection of 0.1 millimeter per volt. The gold leaf system is charged through the intermediary of a sliding condenser, which gives complete control of the potential. The readings of the instrument are very steady; owing, no doubt, to the double case there is apparently a complete absence of disturbances due to convection currents. The gold leaf takes up its position of equilibrium within a small fraction of a second, so that very rapid potential changes can be followed.—C. T. R. Wilson, Proceedings of the Cambridge Philosophical Society, January 31, 1906.

Canal Rays.—J. J. Thomson has studied the properties of the canal rays obtained by means of a perforated cathode by allowing them to impinge upon a charged metal plate mounted in an auxiliary tube at angle to the path of the rays. When the canal rays strike against a solid they cause it to emit cathode rays moving with small velocities. This can easily be shown by charging the metal plate, against which the canal rays impinge negatively to a potential of, say, 80 volts, then from the part of the plate struck by the canal rays a pencil of feebly-luminous rays can be seen. These rays are easily deflected by a magnet in the direction indicating a negative change. The canal rays ionize the gas they traverse, and the presence of electrons is proved by the deflection of portion of the beam toward the plate when charged positively. When the canal rays, consisting as they do of positive ions, lose a certain portion of their velocity, they combine with electrons to form uncharged molecules or atoms. This critical velocity is about the order of 10^8 centimeters per second, but is higher in the α-rays of radium. The canal rays disintegrate a metal plate against which they strike, for after a long-continued bombardment of the metal plate the walls of the tube in the neighborhood of the plate are found to be covered with a deposit of the metal. When the canal rays impinge on a salt of sodium the salt gives out yellow light in which the D line is very bright. It is remarkable that this line is not given out when canal rays impinge on the metal sodium itself. A mirror of sodium with specks of oxide on it presents a beautiful appearance when struck by these rays. The spots of oxide shine out brightly with a greenish-yellow light, while the surface of the metal itself seems quite dull if no external light falls upon it.—J. J. Thomson, Proceedings of the Cambridge Philosophical Society, January 31, 1906.

* Compiled by E. E. Fournier d'Albe in the Electrician.

ELEPHANT-HUNTING IN UPPER INDIA.

By L. De Gruyther.

In Southern India elephants are captured by driving a roaming herd within a large stockade. Thousands of beaters form an enormous circle,

THE CAPTIVE AND HIS GUARDS.

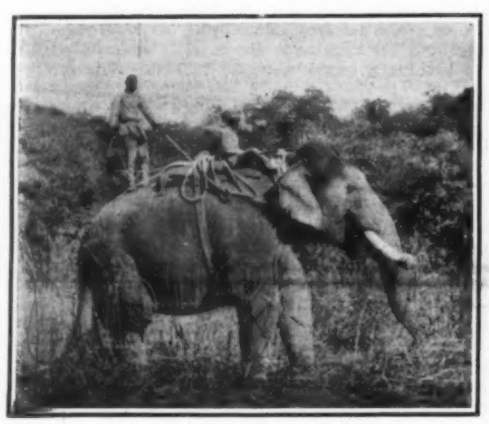
round which fires are kindled at night; the final impulse in the desired direction being given by lighted torches, and, needless to add, a medley of loud noises. Once inside the corral the trapped beasts rush about in the vain search for an outlet—eventually they huddle together in the center for mutual protection. By the trained assistance of tame elephants they are soon securely bound. In Northern India a kheddah is a far more exciting affair. Instead of being merely an interested spectator one joins in the chase.

The system was introduced into British territory some fifty years ago by the late Maharajah of Balrampore, from Nepaul, where he had seen it in operation. His present highness is the largest owner of elephants in the whole of the country, with the exception of the rulers of Mysore and Nepaul. He is constantly adding to his stock, as an elephant-hunt is his favorite recreation. One memorable Christmas I found myself among the visitors assembled to enjoy the novel amusement. We were in camp near the sacred city of Hardwar. The Maharajah's guests for the occasion included the lieutenant-governor of the United Provinces and Lady Digges la Touche, and every possible arrangement had been made to insure good sport. Elephants are thirsty individuals, and generally to be seen in the vicinity of rivers. The Balrampore party had worked its way down from the lower Kumaon ranges toward the Ganges. The forest land lying between the Oudh and Rohilkhund railway line, and the hills a little to the east of Mussoorie, was known to contain herds, and it was confidently hoped that several fine animals would be caught. Of course the number taken by means of a stockade is very much larger than that secured by a chase; the Balrampore hunters, however, have noosed as many as fourteen within one hour. This only when they are on stern duty bound; such hard and dangerous work is not compatible with

CROSSING A FORD.

ELEPHANT-HUNTING IN UPPER INDIA.

Christmas celebrations. Our experiences were limited to one at a time, quite sensational enough for most of us. Elephant-hunting, like other sport, varies, and some days were entirely blank. Generally some ten or twelve miles would be traversed before reaching the nearest point to which a straggler from the herd had been tracked. One of the pictures shows us on the way. Later on the howdahs would be exchanged for pads such as are fastened on the animals bringing up the rear. Thick jungle can only be negotiated along the line of least resistance, and with the least possible impedimenta. A howdah is quite a comfortable conveyance, but a pad is not. Practice alone will enable one to accomplish a long journey without undue fatigue. At first it is difficult to swing the body in harmony with the peculiar pace of the mount, the consequence being much unnecessary strain on the muscles, especially in the case of ladies. The correct position is with the feet dangling behind the mahout (driver),



A KHEDDAH ELEPHANT.

and a pad rope in either hand. The poor mahout often resembles a stringed toy such as babies love, his legs violently agitated against his animal's neck, his arms waving above his head as he does his best to clear obstructive branches from the path of the "sahib-logue" above him. That his own back is meanwhile dug by the points of feminine shoes, and his turban almost dragged from his head by the frenzied clutch of frightened feminine fingers, is all in the day's work.

Arrived at the rendezvous, absolute silence is strictly enjoined. Shrill cries and distant shots indicate the direction from which the quarry may be expected. Our men carry rifles, too, not to shoot with—ordinary bullets would not make much impression on a pachyderm's hide—but to scare away the harried quadruped should he think fit to charge. A sudden crackling, a momentary glimpse of a huge form lumbering past, and the kheddah beasts, like hounds unleashed, are off, the moogriwallahs whacking away at the sensitive spot at the root of the tail to urge their beasts to greater speed. The moogri is a small wooden club into whose rounded end are hammered long nails with protruding heads. A wielder of this severe spur may be seen in the accompanying photograph of a kheddah elephant. Forcing a track through tangled undergrowth, knocking over young saplings, and extricating ourselves from the embarrassing attentions of stronger trees, we tear along. At times the chase lies over a fairly level plain with the panting quarry full in view. More often we are apparently lost in the pathless jungle, even the nearest elephant a few yards away swallowed up by the reedy waves. A startled stag bounds straight across. The nomad we are in quest of must be very close; but where? It is a thrilling moment. Soon a keen-eyed hunter spies him crouching within a thorny thicket. Nagendra Guj, the brave old warrior, hero of a hundred fights, is sent to rout him out, and a fierce combat ensues. It results entirely in favor of the fugitive, whose sharp tusks have drawn blood from Nagendra's defenceless trunk before help arrives. Again and again the beast breaks away, to be made a prisoner at last in spite of gallant struggle or fleet and strategic retreat. One of the photographs shows a prize at the end of days of freedom, his pointed tusks rendering him easily distinguishable from the mob of which he is the central figure. It is only after a year or so of captivity that an elephant is sufficiently subdued to permit the tips of his natural weapons to be sawn off and the edges incased with metal to prevent the splitting of the ivory. The next

LA TOUCHE GUJ ENJOYING A DRINK.

act of the drama is also illustrated. Trained animals press close up against the wild one. Stout ropes securely noosed are passed under their sheltering bodies. One end is attached to a tame elephant, the other is placed near the hind legs of the creature it is intended to shackle. Very cautiously is the animal induced to move one of his ponderous limbs, instant advantage being taken of the action. Heavy strands are deftly twisted round the massive throat, and the operation is complete.

Another illustration gives a good idea of the march back. Weary with his race for liberty the prisoner plods along, pushed and prodded by stern and steady guardians when he stops or flags. In front move leaders to whom he is also fastened. Escape is hopeless, and a sensible animal accepts the inevitable. Like a camel, an elephant is able to provide himself with a certain amount of reserve liquid, about ten gallons. When this is exhausted his Gargantuan thirst can only be quenched at a river or stream. Food is placed within reach of the stretching trunk of a recent capture—though ordinarily his appetite is a formidable thing to appease, in the first days of captivity he is too heart-broken to eat—but for drink he must wait. When conveyed from the trees to which he is tethered to the nearest water supply he goes quietly enough. When it is time to return he sometimes waxes fractious. He feels like a giant refreshed after his long pull, and squirted shower bath, and makes a frantic attempt at regaining his independence. Rush as he may, his escort soon bring him to his bearings, and even the most refractory learns in time to submit to circumstance. Until that merciful knowledge is fully acquired, there are many such scenes as that depicted in the photograph, pitiful fights with fate. Little by little his attendant wins his regard, bit by bit gains his difficult confidence. The primary step toward a good understanding is the application of soothing unguents to relieve the painful cuts of the pressing cords. To catch a baby elephant not able to keep pace with the herd, or separated somehow from its natural protectors, is naturally not a troublesome undertaking. The youngster, who, perhaps, entangles his tender little trunk in the netting rope, thinks it some sort of game. Soon it will be disengaged and firmly fixed around his fat little neck. He will be more easily educated than a bigger brother, though at first his little mind will fail to grasp the situation, and he will give himself much needless discomfort. Accord-

ing to character and capacity is an elephant trained. If of tractable disposition and handsome appearance, he becomes the pride of a state procession, the joy of his faithful mahout; or he may prove of brave and stubborn spirit, and be valued as an indispensable assistant in the work of bringing others of his species from the destructive life of the forest to one of service to mankind. Possibly he turns out just an ordinary catch, a mere beast of burden, a hewer of wood, and drawer of water. Elephant-hunting is the sport of kings, but not necessarily an extravagance.

In their sagacity and self-sacrifice these animals are sometimes an example to their human conquerors. One very fine beast, whose capture we witnessed, was understood to have led his pursuers a long round in order to give his companion time to escape. He did not seek cover in the jungle, but at once made boldly for the open plain. Men skilled in the reading of woodland signs told us afterward that another animal was concealed in the long grass, from whose vicinity brave La Touche Guj drew the chase by the sacrifice of his own freedom. He received the compliment of being named after the popular Lieutenant-Governor, and well deserved the honor, as well as the appellation of Guj, which means king elephant. This noble animal is pictured enjoying a drink. All along his conduct was exemplary. The elephant that enshrined Buddha in one of his numerous incarnations could not have behaved better.

The news of the capture of a wild elephant is hailed with joy by the inhabitants of neighboring villages whose lives have been made hideous by the depredations of nomads. Even a tiny fence will serve to protect fields from a wandering herd—elephants are such suspicious creatures that so slight a defense would savor of a trap—but Indian agriculturists have no visible boundaries at all; the crops appear to melt into each other, and come to a seemingly capricious conclusion.

We returned to the comfortable camp after long days in the brilliant sunshine and invigorating air of an Indian winter, fatigued with the unusual exertion and occasional intense excitement, but heartily desiring a renewal of our novel experiences. All of us very grateful to our hospitable host the Maharajah of Balrampore, to whom we were indebted for the opportunity of participating in unique and most enjoyable sport.—Country Life (London).

THE LAST MOMENT OF FREEDOM.

A PITIFUL FIGHT WITH FATE.

IN THE PATHLESS JUNGLE.

ELEPHANT-HUNTING IN UPPER INDIA.

HOLES IN THE HEAVENS.*

By J. E. Gore, F.R.A.S.

There are many dark spots in the Milky Way which seem to be openings or holes in that wonderful zone of stars. These dark spots, or "coal sacks," as they are also called, seem to have been first noticed by Pinzon in 1499. They were also described by Lacaille in 1763.

The most remarkable of these spots is the well-known coal sack near the Southern Cross. It is of roughly oval or pear-shaped form, about 8 deg. in length by 5 deg. in width, and forms a conspicuous object in the sky of the southern hemisphere. It is completely surrounded by the nebulous light of the Milky Way, which is here of considerable brilliancy. The bright stars α and β Crucis—the brightest stars of the Southern Cross—nearly touch its southeastern edge. It contains only one lucid star within its boundaries. With reference to its northern border Sir John Herschel says: "The transition from rich Milky Way to almost complete darkness is here very sudden." It is, however, by no means devoid of faint stars. On a photograph taken in 1891 by Mr. H. C. Russell, at the Sydney Observatory, numerous very small stars are visible, but there are several spots which seem to be completely void of stars, and absolutely black. One of these remarkable holes is near β Crucis, and another near α Crucis.

There are other remarkable coal sacks in the Milky Way. A long, narrow, dark spot runs from α Centauri for several degrees toward the northeast. There are several in Scorpio, one of larger size between β and ϵ Cygni, and one south of α Cygni.

Examined with a telescope, the Milky Way shows many examples of small coal sacks; and some may be seen with even a good binocular field glass. One night when Sir William Herschel was examining a part of the Milky Way closely east of the globular cluster 80 Messier, which lies between ν and o Scorpii, he suddenly exclaimed to his sister—the famous Caroline Herschel—"Hier ist wahrhaftig ein Loch im Himmel" (here, truly, is a hole in the heavens). It was an absolutely black vacuity, about four degrees in width, perfectly free from any stars, and especially remarkable owing to its proximity to one of the richest globular clusters in the heavens. Closely south of Herschel's dark hole just mentioned, Prof. Barnard has photographed a great nebulous region surrounding the stars ρ Ophiuchi and 22 Scorpii. This photograph shows several dark lanes in what seems to be at least a comparatively thin sheet of stars, and this distinguished astronomer thinks it is certain that these stars are at the same distance as the nebula, for they form part of it. With reference to the Milky Way in general, he thinks that the stars comprising it are comparatively very small bodies, and that they consequently differ vastly in point of size, at least, from the ordinary stars of the sky. If this be so, and the evidence seems to point in this direction, it would follow that their distance from the earth is not so great as their faintness would lead us to imagine. In his "Cape Observations," Sir John Herschel gives a list of 49 spots in the southern hemisphere totally devoid of any perceptible star. But probably photography will reveal the presence of some faint stars in these dark spots.

Closely east of the star θ Ophiuchi is a dark chasm, which passes south and west of that star, and there are several other dark lanes and holes clearly visible on the photograph taken by Prof. Barnard at the Lick Observatory.

Another small black spot was observed by Barnard a little northwest of the star γ Sagittarii. This seems to have been previously seen by Trouvelot, who says: "C'est comme un sac à charbon en miniature, ou une ouverture de la Voie Lactée à travers laquelle la vue pénètre au delà de ce grand assemblage d'étoiles."

A little southeast of α Cephii, a photograph by Barnard shows a ring of nebulous light, with a comparatively dark interior; at least the stratum of stars filling the rings seems pierced by several holes.

The "key-hole" openings in the great nebula surrounding the variable star η Argûs is a remarkable feature of that wonderful nebula. A little south of this hole there is a kidney-bean shaped opening, shown in Sir John Herschel's drawing in the "Cape Observations." This opening is visible on a photograph taken by Sir David Gill in March, 1892. The photograph confirms the accuracy of Herschel's drawing, and shows that the opening is in all probability a real hole through the surrounding nebulous matter.

In the region round the star 12 Monocerotis there is a remarkable nebula of irregular shape, somewhat resembling in its general character the great nebula in the sword of Orion. Dr. Roberts, describing a photograph he took of this nebula, says: "Some remarkable tortuous rifts meander through the nebulosity on the north preceding half of the nebula; their margins are sharp and well defined in the midst of dense nebulosity. They are as clearly cut as we see the canyons of great rivers, but their width may in reality be millions of miles, for we have no reason to assume that the nebula is nearer to the earth than the stars. It is, indeed, possible that the stars which dot the surface are nearer to us than the nebula."

About 3 deg. northeast of the star θ Canis Majoris is another nebula of irregular shape. Dr. Roberts says that the star D.M. 1848 is on the margin of a dark sinuous vacancy or rift in the nebula, through which we see into the starless vacancy of space beyond it. This opening closely resembles the "key-hole" opening in the great nebula in Argûs. Dr. Roberts adds: "These vacancies are most conspicuously seen where the surrounding nebulosity is dense, though they are also visible in some parts where it is relatively faint. The margins of the vacancies are often sharply defined, and suggestive of the idea that in consequence of some internal strain, operating from opposite directions, the nebula was rent asunder, and the parts separated from each other."

In another nebula in Monoceros, photographed by Dr. Roberts, a little west of the triple star 15 Monocerotis, there is a remarkable vacuity or hole. Dr. Roberts calls it a dark tortuous rift, and says: "The rifts prove that the nebulæ are not globular, but are like clouds with relatively small depths, and that we can see through them into the darkness of space beyond." There are also very noticeable areas devoid of stars in the region surrounding the nebula.

On July 12, 1891, Prof. Max Wolf, of the Astrophysical Observatory of Heidelberg, discovered three

* Knowledge and Scientific News.

dark markings in the Milky Way, about $1\frac{1}{2}$ deg. west of the star γ Aquilæ. He calls them the "triple caves," and they certainly present a very remarkable appearance on his photograph. Closely east of the same star, a photograph taken by Barnard shows some curiously shaped dark markings, which seem to be openings through the Milky Way in this region. On a photograph by Max Wolf, of the region near ξ Cygni, there is a remarkable black hole and smaller ones.

The question naturally suggests itself, what is the real nature of these curious black spots? Some astronomers have suggested that they are due to masses of cooled down, or partially cooled down, nebulous matter which absorbs the light of stars behind them. The term "hole," which I have used in the present paper, implies that my own view is that they are really holes or openings through the regions of stars or nebulous matter, and in this view of the matter I am supported by the opinion of several astronomers, as some of the extracts quoted above will show. Photographs of the great coal sack near the Southern Cross prove conclusively, I think, that the darkness of this remarkable spot is due to a real paucity of stars compared with the richness of the surrounding regions, and probably the same thing is true of the other dark spots in the Milky Way. We have really no evidence of the existence of dark bodies in space. Prof. Newcomb thinks that there is probably little or no extinction due to dark bodies, and he says, "We may say with certainty that dark stars are not so numerous as to cut off any important part of the light from the stars of the Milky Way, because, if they did, the latter would not be so clearly seen as it is. Since we have reason to believe that the Milky Way comprises the more distant stars of our system, we may feel fairly confident that not much light can be cut off by dark bodies from the most distant regions to which our telescopes can penetrate. Up to this distance, we see the stars just as they are."* The companions of some of the Algol variables are usually spoken of as dark bodies, but I have shown elsewhere that we have no reason to think that they are really dark. The companion of Algol, for example, may be a star of the 5th magnitude—a comparatively bright star—and yet be quite invisible to us, as neither the telescope nor spectroscope would show any trace of its existence. The little evidence we have tends to show that the satellite of Algol is *not* a dark body. The idea of "dark bodies" and "dark stars" seems to have been based on the existence of this eclipsing satellite; but it has been recently found that a difference of brightness of two magnitudes between the components of a spectroscopic binary star—like Algol—would be quite sufficient to obliterate the spectrum of the fainter star, the spectroscope merely showing the spectrum of the brighter component. Dark bodies *may* exist in space, and probably do, but as yet we have no positive evidence of their existence. The "holes in the heavens" are, I think, real, and "dark companions" of Algol variables have probably no existence except in the imagination of some astronomical writers.

It has been stated by several writers that the existence of these holes indicates that the Milky Way has a small extension in the line of sight; or, in other words, that it forms a comparatively thin stratum of stars. But Prof. Seeliger has shown that, according to the law of probabilities, if the number of stars be the same in both cases, the probability against the occurrence of these holes is just *the same* whether the extension of the Milky Way in the line of sight be great or small.† We cannot, therefore, come to any conclusion as to the actual thickness of the Milky Way from the appearance of the dark spots. It may have a great extension in the line of sight, or it may be comparatively thin in that direction. The cause of these holes must probably be looked for in the influence of some clustering power, as Sir William Herschel termed it, which tends to draw the stars away from certain spots and accumulate them in others. The existence of globular and other clusters close to dark and comparatively starless spots seems very suggestive in this connection. If these dark spots were due to intervening dark bodies, there seems to be no reason why we should find them so often close to rich regions.

[Continued from SUPPLEMENT No. 1584, page 25379.]

VALUABLE ALLOYS.—V.

BISMUTH ALLOYS.

Cliché Metal.

THIS alloy is composed of tin 48 parts, lead 32.5, bismuth 9, and antimony 10.5. It is especially well adapted to dabbing rollers for printing cotton goods, and as it possesses a considerable degree of hardness, it wears well.

For filling out defective places in metallic castings, an alloy of bismuth 1 part, antimony 3, lead 8, can be advantageously used.

Alloys of Bismuth, Tin, and Lead.

The readily fusible alloys of bismuth, tin, and lead have a somewhat higher melting point than those containing cadmium; they were earlier known than these, and are used for various purposes. Newton's metal and Rose's alloys are included here.

Newton's metal consists of bismuth 8 parts, lead 5, tin 3. It melts at 202 deg. F.

Rose's alloys consist of:

	I.	II.
Bismuth	2	8
Tin	1	3
Lead	1	8

* Harper's Magazine, October, 1904.
† Astrophysical Journal, vol. 12, p. 377.

The first of these alloys melts at 200.75 deg. F., and the other at 174.2 deg. F. They were formerly used in the manufacture of the so-called safety plates inserted in the top of steam boilers. These plates were intentionally made of a readily fusible alloy, so that at a certain temperature, corresponding to a certain pressure in the interior of the boiler, they would become fluid, and allow the steam to escape through the opening thus made. They were to act as a sort of safety valve, to prevent the explosion of the boiler with too high a pressure of steam. But however correct the principle may appear, it was found in practice that the boilers would frequently explode without the plates having melted; and they are at the present time hardly used at all. Chemical and physical tests have shown that by long-continued heating of the plates new alloys are formed, whose melting points are much higher than those of the original compositions. The following table gives the compositions of some alloys which are said to melt, if the pressure of the steam exceeds that indicated:

Bismuth.	Lead.	Tin.	Melting Point, Degrees F.	Corresponding Pressure of Steam in Atmospheres.
8	5	3	212.0	1
8	8	4	235.9	$1\frac{1}{2}$
8	8	8	253.9	2
8	10	8	266.0	$2\frac{1}{2}$
8	12	8	270.3	3
8	16	14	289.5	$3\frac{1}{2}$
8	16	12	300.6	4
8	22	24	308.8	5
8	32	36	320.3	6
8	32	28	331.7	7
8	30	24	341.6	8

Bismuth Alloys for Delicate Castings.

For delicate castings, and for taking impressions from dies, medals, etc., various bismuth alloys are in use, whose composition corresponds to the following figures:

	I.	II.	III.	IV.
Bismuth	6	5	2	8
Tin	3	2	1	3
Lead	13	3	1	5

These alloys have the property, very favorable in making sharply outlined castings, that they expand strongly on cooling, and so fill out the finest elevation and depressions of the mold.

Bismuth Alloy for Cementing Glass.

Most of the cements in ordinary use are dissolved, or at least softened, by petroleum. An alloy of lead 3 parts, tin 2, bismuth 2.5, melting at 212 deg. F., is not affected by petroleum, and is therefore useful for cementing lamps made of metal and glass combined.

SILVER ALLOYS.

Silver and Aluminium Alloy.

Aluminium and silver form beautiful white alloys, which are considerably harder than pure aluminium, and take a very high polish. They have the advantage over copper alloys of being unchanged by exposure to the air, and retaining their white color. It has been proposed to alloy coins with aluminium instead of copper, as this would make them much more durable, and they would keep their bright color; but the results of experiments made on a large scale did not warrant the change.

The properties of aluminium and silver alloys vary considerably according to the percentage of aluminium. An alloy of 100 parts of aluminium and 5 parts of silver is very similar to pure aluminium, but is harder and takes a fine polish. One hundred and sixty-nine parts of aluminium and 5 of silver makes an elastic alloy, recommended for watch springs and dessert knives. An alloy of equal parts of silver and aluminium is as hard as bronze.

Tiers-Argent.

This alloy is chiefly prepared in Paris, and used for the manufacture of various utensils. As indicated by its name (one-third silver) it consists of 33.33 parts of silver and 66.66 parts of aluminium. Its advantages over silver consist in its lower price and greater hardness; it can also be stamped and engraved more easily than the alloys of copper and silver.

Alloys of Silver and Zinc.

Silver and zinc have great affinity for each other, and alloys of these two metals are therefore easily made. The required quantity of zinc, wrapped in paper, is thrown into the melted and strongly-heated silver, the mass is thoroughly stirred with an iron rod, and at once poured out into molds. Alloys of silver and zinc can be obtained which are both ductile and flexible. An alloy consisting of 2 parts of zinc and 1 of silver closely resembles silver in color, and is quite ductile. With a larger proportion of zinc the alloys become brittle. In preparing the alloy, a somewhat larger quantity of zinc must be taken than the finished alloy is intended to contain, as a small amount always volatilizes.

Alloys of Silver, Copper, Nickel, and Zinc.

These alloys, from the metals contained in them, may be characterized as argentan or German silver with a percentage of silver. They have been used for making small coins, as in the older coins of Switzerland. Being quite hard, they have the advantage of wearing well, but soon lose their beautiful white color and take on a disagreeable shade of yellow, like poor brass. The silver contained in them can only be regained by a laborious process, which is a great drawback to their use in coinage.

The composition of the Swiss fractional coins is as follows:

	20 centimes.	10 centimes.	5 centimes.
Silver	15	10	5
Copper	50	55	60
Nickel	25	25	25
Zinc	10	10	10

Mousset's Silver Alloy.

Copper 59.06, silver 27.56, zinc 9.57, nickel 3.42. This alloy is yellowish with a reddish tinge, but white on the fractured surface. It ranks next after Argent-Ruolz, which also contains sometimes certain quantities of zinc, and in this case may be classed together with the alloy just described. The following alloys can be rolled into sheet or drawn into wire:

	I.	II.	III.
Silver	33.3	34	40.0
Copper	41.8	42	44.6
Nickel	8.6	8	4.6
Zinc	16.3	16	10.8

Silver Alloys Containing Arsenic.

Alloys which contain small quantities of arsenic are very ductile, have a beautiful white color, and were formerly used in England in the manufacture of table ware. They are not, however, suitable for this purpose, on account of the poisonous character of the arsenic. They are composed usually of 49 parts of silver, 49 of copper, and 2 of arsenic.

Alloys of Copper, Silver, and Cadmium.

Cadmium added to silver alloys gives great flexibility and ductility, without affecting the white color; these properties are valuable in the manufacture of silver-plated ware and wire. The proportions of the metals vary in these alloys. Some of the most important varieties are given below:

	I.	II.	III.	IV.	V.	VI.	VII.
Silver	980	950	970	860	666	667	500
Copper	15	15	18	20	25	50	50
Cadmium	5	35	82	180	309	284	450

In preparing these alloys, the great volatility of cadmium must be taken into account. It is customary to prepare first the alloy of silver and copper, and add the cadmium, which, as in the case of the alloys of silver and zinc, must be wrapped in paper. After putting it in, the mass is quickly stirred, and the alloy poured immediately into the molds. This is the surest way to prevent the volatilization of the cadmium.

Gray Silver (Japanese Silver).

An alloy is prepared in Japan which consists of equal parts of copper and silver, and which is given a beautiful gray color by boiling in a solution of alum, to which copper sulphate and verdigris are added. The so-called "mokum," also a Japanese alloy, is prepared by placing thin plates of gold, silver, copper, and the alloy just described over each other and stretching them under the hammer. The cross sections of the thin plates obtained in this way show the colors of the different metals, which gives them a peculiar striped appearance. Mokum is principally used for decorations upon gold and silver articles.

Imitation Silver Alloys.

There are a number of alloys, composed of different metals, which resemble silver, and may be briefly mentioned here.

Warne's metal is composed of tin 10 parts, nickel 7, bismuth 7, and cobalt 3. It is white, fine grained, but quite difficult to fuse.

Tonca's metal contains copper 5 parts, nickel 4, tin 1, lead 1, iron 1, zinc 1, antimony 1. It is hard, difficult to fuse, not very ductile, and cannot be recommended.

Trabuk metal contains tin 87.5, nickel 5.5, antimony 5, bismuth 5. This is similar to Warne's metal.

Tourun-Leonard's metal is composed of 500 parts of tin and 64 of bell metal.

Minargent.

This alloy, which is of a beautiful white color, contains no silver, but is made of copper, tungsten, aluminium, and nickel in the proportions of 1,000 parts of copper, 700 of nickel, 50 of tungsten, and 10 of aluminium.

GOLD ALLOYS.

Alloys of Gold and Palladium.

Alloys of gold, copper, silver, and palladium have a brownish red color and are as hard as iron. They are sometimes (although rarely) used for the bearings for the axles of the wheels of fine watches, as they cause less friction than the jewels commonly used for the purpose, and do not rust in the air. The composition used in the Swiss and English watch factories consists usually of gold 18 parts, copper 13, silver 11, and palladium 6.

Aluminium and Gold Alloy.

This alloy, called Nuremberg gold, is used for making cheap gold ware, and is excellent for this purpose, as its color is exactly that of pure gold, and does not change in the air. Articles made of Nuremberg gold need no gilding, and retain their color under the hardest usage; even the fracture of this alloy shows the pure gold color. The composition is usually 90 parts of copper, 2.5 of gold, and 7.5 of aluminium.

Colored Gold.

The alloys of gold with copper have a reddish tinge, those of gold with silver are whiter, and an alloy of gold, silver, and copper together is distinguished by a greenish tone. Manufacturers of gold ware make use of these different colors, one piece being frequently composed of several pieces of varying color. Below are given some of these alloys, with their colors:

Gold.	Silver.	Copper.	Steel.	Cadmium.	Color.
20 to 6.0	1.0	....	....	....	Green
75.0	16.6	....	....	8.4	Green
74.6	11.4	9.7	....	4.3	Green
75.0	12.5	12.5	....	12.5	Green
1.0	2.0	....	....	....	Pale Yellow
4.0	3.0	1.0	....	....	Deep Yellow
14.7	7.0	6.0	....	....	Deep Yellow
14.7	9.0	4.0	....	....	Deep Yellow
3.0	1.0	1.0	....	....	Light Red
10.0	1.0	4.0	....	....	Light Red
1.0	....	1.0	....	....	Bright Red
1.0	....	2.0	....	....	Bright Red
30.0	3.0	....	2.0	....	Gray
4.0	....	....	1.0	....	Gray
29.0	11.0	....	....	....	Gray
1.0 to 3.0	....	....	1.0	....	Blue

PLATINUM ALLOYS.

Platinum and Gold Alloys.

Small quantities of platinum change the characteristics of gold in a considerable degree. With a very small percentage, the color is noticeably lighter than that of pure gold, and the alloys are extremely elastic; alloys containing more than 20 per cent of platinum, however, almost entirely lose their elasticity. The melting point of the platinum-gold alloy is very high, and alloys containing 70 per cent of platinum can be fused only in the flame of oxyhydrogen gas, like platinum itself. Alloys with a smaller percentage of platinum can be prepared in furnaces, but require the strongest white heat. In order to avoid the chance of an imperfect alloy from too low a temperature, it is always safer to fuse them with the oxyhydrogen flame. The alloys of platinum and gold have a somewhat limited application; those which contain from 5 to 10 per cent of platinum are used for sheet and wire in the manufacture of artificial teeth.

Platinum and Gold Alloys for Dental Purposes.

	I.	II.	III.
Platinum	6	14	10
Gold	2	4	6
Silver	1	6	..
Palladium	..	..	8

Alloys of Platinum and Silver.

An addition of platinum to silver makes it harder, but also more brittle, and changes the white color to gray; an alloy which contains only a very small percentage of platinum is noticeably darker in color than pure silver. Such alloys are prepared under the name of "platine au titre," containing between 17 and 35 per cent of platinum. They are almost exclusively employed for dental purposes.

Golden Yellow Alloys of Platinum and Copper.

Alloys whose composition is such that they resemble pure gold in color are well suited to the manufacture of jewelry and other ornamental articles. They can be prepared for about twice the cost of silver, and are not only much cheaper than gold, and equally beautiful in color, but considerably more durable.

The composition of these alloys of platinum and copper, employed in making jewelry, varies exceedingly. A few of the compositions are here given:

	I.	II.	III.	IV.
Platinum	2	20	7	3
Copper	5	..	16	13
Zinc	..	..	1	..
Silver	1	20	..	..
Brass	2	240	..	..
Nickel	1	120	..	..

The alloy numbered IV., called Cooper's gold, is most excellent for manufacturing jewelry, since its color cannot be distinguished from that of 18-carat gold, even by close comparison. It can be drawn out without difficulty to the finest wire, and rolled into very thin sheets.

Other alloys of the same nature are composed as follows:

	I.	II.	III.	IV.
Platinum	15	16	7	6
Copper	10	7	16	23
Zinc	1	1	1	..

The successful preparation of these alloys depends upon one condition, namely, that the metals shall be entirely free from iron. If this is not the case, the alloys will indeed show the requisite color, but will be too hard, and so brittle that they cannot be drawn out into thin sheet or fine wire. It has been found by accurate experiment that a very small percentage of iron is sufficient to lessen the ductility considerably; an 8-1,000 part of the weight of the alloy will make it noticeably brittle. The metals used in preparing the alloy must therefore be tested beforehand for the presence of iron, and any which contain the slightest trace of it excluded.

Cooper's Mirror Metal.

Copper 35 parts, platinum 6, zinc 2, tin 16.5, arsenic 1. On account of the hardness of this alloy, it takes a very high polish; it is impervious to the effects of the weather, and is therefore remarkably well adapted to the manufacture of mirrors for fine optical instruments.

Cooper's Pen Metal.

This alloy is especially well adapted to the manufacture of pens, on account of its great hardness, elasticity, and power of resistance to atmospheric influences, and would certainly have superseded steel, if it were possible to produce it more cheaply than is the case. The compositions most frequently used for pen metal are copper 1 part, platinum 4, and silver 3; or copper 12, platinum 50, and silver 36.

Pens have been manufactured, consisting of several sections, each of a different alloy, suited to the special purpose of the part. Thus, for instance, the sides of the pen are made of the elastic composition just described; the upper part is of an alloy of silver and platinum, and the point is made either of tiny cut rubies, or of an extremely hard alloy of osmium and iridium, joined to the body of the pen by melting in the flame of the oxyhydrogen blowpipe. The price of such pens, made of expensive materials, and at the cost of great labor, is of course exceedingly high, but their excellent qualities repay the extra expense. They are not in the least affected by any kind of ink, are most durable, and can be used constantly for years without showing any signs of wear.

The great hardness and resistance to the atmosphere of Cooper's alloys make them very suitable for manufacturing mathematical instruments where great precision is required. It can scarcely be calculated how long a chronometer, for instance, whose wheels are constructed of this alloy, will run before showing any irregularity due to wear. In the construction of such instruments, the price of the material is not to be taken into account, since the cost of the labor in their manufacture so far exceeds this.

PALLADIUM ALLOYS.

Palladium and Silver Alloy.

This alloy, composed of 9 parts of palladium and 1 of silver, is used almost exclusively for dental purposes, and is very well suited to the manufacture of artificial teeth, as it does not oxidize. An alloy even more frequently used than this consists of platinum 10 parts, palladium 8, and gold 6.

Palladium Bearing Metal.

This alloy is extremely hard, and is said to cause less friction upon axles of hard steel than the bearings made of rubies (jewel holes) generally employed in fine watches. It is composed of palladium 24 parts, gold 72, silver 44, and copper 92.

Other Palladium Alloys.

An alloy of palladium 20 parts, gold 80, is white, hard as steel, unchangeable in the air, and can, like the other alloys of palladium, be used for dental purposes. Palladium 6 parts, gold 18, silver 11, and copper 13, gives a reddish brown, hard, and very fine-grained alloy, suitable for the bearings of pivots in clock works.

The alloys of the other platinum metals, so called, are little used on account of their rarity and costliness. The alloys of platinum and iridium are only used for special scientific purposes, such as for standard scales, etc. Iridium and rhodium give great hardness to steel, but the commercial rhodium and iridium steel, so called, frequently contains not a trace of either. The alloy of iridium with osmium has great hardness and resistance and is recommended for pivots, fine instruments, and points of ships' compasses.

Alloys for Watch Manufacturers.

Some very tenacious and hard alloys, for making the parts of watches which are not sensitive to magnetism, are as follows:

	I.	II.	III.	IV.	V.	VI.	VII.
Platinum	62.75	62.75	62.75	54.32	0.5	0.5	....
Copper	18.00	16.20	16.20	16.00	18.5	18.5	25.0
Nickel	18.00	18.00	16.50	24.70	....	2.0	1.0
Cadmium	1.25	1.25	1.25	1.25	....	....	....
Cobalt	....	....	1.50	1.96	....	....	....
Tungsten	....	1.80	1.80	1.77	..	....	....
Palladium	....	....	....	....	72.0	72.0	70.0
Silver	....	....	....	....	6.5	7.0	4.0
Rhodium	....	....	....	....	1.0	....	....
Gold	....	....	....	....	1.5	....	....

—Translated from A. Krupp in Die Legierungen.

RELATIVE CORROSION OF WROUGHT IRON AND STEEL.*

By PROF. H. M. HOWE.

ON one hand we have the very general opinion that steel corrodes not only faster but very much faster than wrought iron, an opinion held so widely and so strongly that it cannot be ignored. Smoke does not prove that fire exists; but such strong smoke bids us look carefully for fire. On the other hand we have the results of direct experiments by a great many observers, in different countries and under widely differing conditions; and these results certainly tend to show that this popular belief is completely wrong, and that on the whole there is no very great difference between the corrosion of steel and wrought iron. Under certain sets of conditions steel seems to rust a little faster than wrought iron, and under others wrought iron seems to rust a little faster than steel. Thus taking the tests in unconfined sea water as a whole wrought iron does constantly a little better than steel; and its advantage seems to be still greater in the case of boiling sea water. In the few tests in alkaline water wrought iron seems to have the advantage over steel, whereas in acidulated water steel seems to rust more slowly than wrought iron.

We, as technical and scientific men, naturally attach greater weight to the numerical results of careful direct comparative tests than to rumor and popular belief. When ultra-conservative engineers used to cry out against steel boilers, it seemed to us like the old cry: "Great is Diana of the Ephesians." Those who raised the cry, cried what they firmly believed was true, and what they thought every sensible man knew to be true. But they were wrong; and I need not tell this society that such cries and popular beliefs, even when widely and firmly held, often prove wrong. Compared with the results of direct comparative tests such beliefs have the great disadvantage of lacking all precise and definite foundation; they are easily spread from man to man. The fact that steel has come into wide use simultaneously with a great increase in the sulphurous acid in our city air and of strong electric currents in our city ground, may well lead the practical man, to be hasty or cautious, into inferring that the rapid corrosion of to-day is certainly due to the new material of to-day, steel, whereas in fact it may be wholly due to the new conditions of to-day, sulphurous acid and electrolysis. At the same time, while popular belief has the disadvantage of lacking direct numerical comparative data, it has the very great advantage of being based on the actual conditions of use, more closely, and often far more closely, than our direct comparative tests are, unless these are planned with very great care.

In view of this great discrepancy between popular belief and the results of our direct tests, it behooves us who have relied chiefly on the results of these latter to examine their conditions carefully, to see whether they really have represented fairly the conditions of actual industrial use and service, in such a way that there is a real difference between the corrosion of steel and that of wrought iron, such a difference as would become manifest. In short, have our direct comparative tests been trustworthy?

Now, when I review our conditions in the light of this apparent contradiction between popular belief and the results of the differences between steel and wrought iron which ought to cause a difference in their rapidity of rusting, there are three prominent differences: (1) blowholes; (2) manganese; and (3) the presence of cementite in the steel, and of cinder in the wrought iron. Let us take up these in order and see how they require that direct tests should be very prolonged or pushed to destruction.

(1) Blowholes exist in steel but not in wrought iron. But blowholes, at least blowholes which do not weld up and thus cease to exist, are not necessary. Yet they are to be prevented only by care and skill. Hence, get your steel only from careful and trustworthy makers.

(2) Steel always and almost necessarily contains more manganese than wrought iron. This may or may not hasten its rusting. If it does, then its effects ought to be made manifest even in short-time tests. From the fact that such tests do not show that steel rusts materially faster than wrought iron, I infer that this manganese is probably not a serious cause of rusting.

(3) Steel is generally richer than wrought iron in cementite, the iron carbide Fe_3C. Wrought iron always contains very much more cinder than steel. Each of these substances, the cementite of the steel and the cinder of the wrought iron, may have a double influence on corrosion, hastening it through difference of potential and retarding it by acting as a mechanical barrier like so much paint, to exclude the oxygen of the air or the water. It is not clear that the influence of difference of potential ought to change materially as corrosion proceeds; but it is clear that mechanical protection given by the plates of cementite and of cinder ought to increase as corrosion proceeds. When a piece of wrought iron, for instance, is first exposed to corrosion, only the outcrops, so to speak, of the sheets of cinder come to the surface; its mechanical protection is very small. But as corrosion proceeds, and more of the metal which at first overlies the sheets of cinder is eaten away, the remaining cinder forms a larger and larger proportion of the outer surface, and therefore protects a constantly increasing proportion of the underlying metal from corrosion. In short, the mechanical protection afforded by the cinder ought to increase as corrosion proceeds. Here, then, is a cause which, as corrosion proceeds, should continuously tend to retard the corrosion of wrought iron, and to make it compare more and more favorably with steel. But, in like manner, as steel is gradually corroded away, more and more of its surface should come to be composed of cementite, and this fact should tend to retard corrosion of steel, because cementite, too, should protect the underlying free iron or ferrite.

These causes may, in time, reverse the initial relative rapidity of rusting of steel and wrought iron. Steel which in the first few months may rust faster than wrought iron may, on greatly prolonging the experiments, or pushing them to destruction, actually rust more slowly, and *vice versa*.

Now of the two, the cinder of wrought iron ought to gain more than the cementite of the steel, in its value as a mechanical retarder of corrosion, as time goes on and more and more of the metal is eaten away. The reason for this is that the cementite is in such extremely minute microscopic plates that the eating away of a very small quantity of the iron from above them ought to bring very nearly the full proportion of this cementite to the surface; whereas the much larger and more distantly scattered plates of cinder in wrought iron would not constitute their full share of the surface until a much thicker layer of initially overlying metal had been eaten away. This, then, may be the true explanation: that is, the reason why steel does not rust faster than wrought iron in our direct tests, though it does in actual use, is that our direct tests are too short to bring out the full protective action of the cinder of the wrought iron. Or the reverse may be true. As time goes on, the harmful effect of the difference of potential of the cinder may grow more than its protective action. Let us, therefore, henceforth push our tests to destruction.

Two other points: Sheet-steel roofing may rust faster than iron because it holds the paint better, and yet steel in other forms, like tubing, may rust no faster than wrought iron. Again let me emphasize the difference between different steels. Carelessly made steel, containing blow-holes, may rust faster than wrought iron, yet carefully made steel, free from blowholes,

* Read before the American Society for Testing Materials.

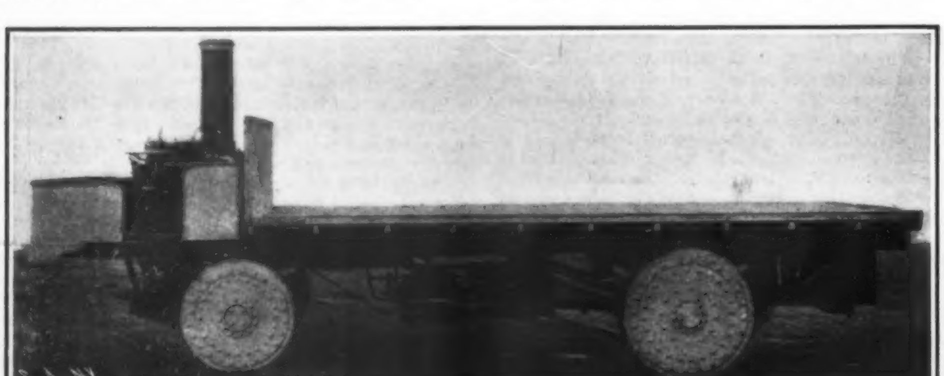
may rust more slowly. Recognize that any difference between the two may be due not to the inherent and intrinsic nature of the material, but to defects to which it is subject if carelessly made. Care in manufacture and special steps to lessen the tendency to rust, might well make steel less corrodible than wrought iron, even if steel carelessly made should readily prove more corrodible than wrought iron.

THE HAY RATCHET-AND-PAWL-PROPELLED STEAM LORRY WITH CRANKLESS ENGINE AND GEARLESS DRIVE.

By the English Correspondent of Scientific American.

An interesting new type of steam-propelled motor vehicle, which possesses numerous new and novel features in automobile practice, has been invented by Mr. W. G. Hay, a well-known British automobile engineer. Briefly, the most salient points of this vehicle are the absence of any cranks or crankshaft to the engine, the elimination of change-speed gearing and its attendant complications, and the perfection of a system of propulsion by ratchet and pawl. One of these vehicles of six tons capacity has been constructed by the Hay Motor Company, of Preston (Lancashire) for the heaviest classes of work at the Liverpool docks, to compete with the animal haulage at present in vogue, and the system has proved so completely successful in practical operation, that it is being applied to power omnibuses and other industrial vehicles.

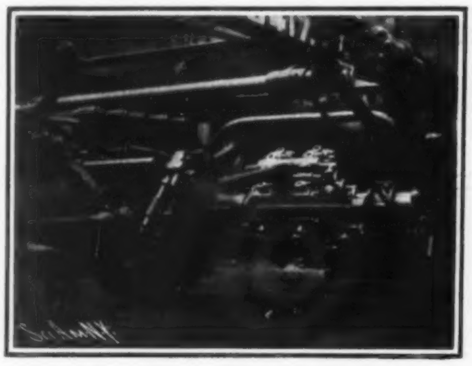
By means of this design the control and working of the vehicle is considerably facilitated, the initial cost is reduced by one-third or one-half of the ordinary type of steam lorry, excessive vibration is overcome with its attendant wear and tear, and the number of integral working parts decreased, so that in the hands of an inexperienced driver no serious difficulties need be anticipated. In evolving his design, however, the inventor quickly ascertained that in order to eliminate all gearing and countershafts, the engine would necessarily have to run at a slow speed. The Hay motor has one high-pressure cylinder and one piston rod, and works at about 80 strokes per minute—the average steam vehicle has a high-speed engine running at some 600 revolutions. At the crosshead of the engine are attached two connecting rods, and instead of the latter being secured to cranks on a revolving shaft, the end of each rod surrounds a strong spindle. There is a casting containing four pawls attached to each end of the two spindles, two for forward motion and two for reverse, thus giving eight forward and eight reverse pawls respectively. There are two ratchet wheels fixed to sleeves on the main axle carrying the road wheels at either end, and a pawl casting is mounted at both top and bottom of each ratchet wheel, with the teeth of which they engage. There is no rotary, but purely a reciprocatory motion, since as the piston moves backward and forward the connecting rods follow the same motion in complete unison, thereby imparting a constant rotary motion to the ratchet wheels. On the backward stroke the lower connecting rod causes the pawls to which it is connected to engage with the ratchet wheel, forcing it upward and forward, the pawls on the upper rod simply slipping over the teeth. On the forward stroke of the piston, however, the pawls connected to the upper rod in turn engage with the ratchet teeth, pulling them downward and forward, the pawls on the lower rod simply slipping in their turn, and in this alternate motion the propulsion is obtained. The rear axle is solid from wheel to wheel, and each of the latter having its own sleeve carrying a ratchet wheel is thus able to revolve independently of the other, this arrangement dispensing with a differential gearing. In order to avoid the possibility of any shocks to the mechanism when starting or running, a series of springs are incorporated, which take up the initial motion, and transmit it gently to the road wheels, thereby enabling the vehicle to be started quietly and gradually. The pawl cases or



THE HAY SIX-TON LORRY DRIVEN BY PAWL AND RATCHET WITH CRANKLESS ENGINE.

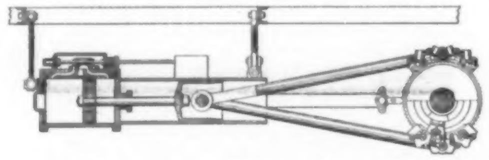
clutches are made in two pieces bolted securely together. A grooved lip is formed, and within this revolve the flanges of the ratchet wheels, so that the shoes are always maintained in the same relative positions. The pawl cases are mounted in pairs upon a pin, which carries one of the connecting rods. Although there are four pairs of pawls attached to each connecting rod, only two pairs on each rod are brought into operation for the forward drive, the remaining pairs being quiescent until a reverse motion to the vehicle is required. The forward driving pawls both on the upper and lower rods are then tripped out of gear, and the reverse pawls brought into action. The motion is now exactly opposite. On the forward action of the piston the reverse pawls on the lower connecting rod force the ratchet wheel upward and backward, while on the backward stroke of the piston the pawls on the upper rods push the ratchet downward and backward.

The engine has a bore of 10 inches and a stroke of



UNDER VIEW OF STEAM LORRY, SHOWING ENGINE, VALVE MOTION, CONNECTING RODS, AND DRIVING MECHANISM.

12 inches, and is suspended from the chassis frame by universal joints, and the radial stays at the trunk end are also swiveled, so that no part of the mechanism is liable to twist or strain. The valve gear in the vehicle at work at the Liverpool docks is somewhat elaborate, but in the later vehicles it has been considerably simplified. In this lorry the engine receives the steam through a D valve over the cylinder, and a cut-off piston valve carried on the trunk. The piston valve controls the supply of steam to the main valve by a trip gear operated from the crosshead. There is a lever on each side of the crosshead, to the upper end of which is attached two springs, and the outer ends of the latter are attached to the valve spindle in such a way that during the piston stroke the springs



SECTION OF DRIVING MECHANISM.

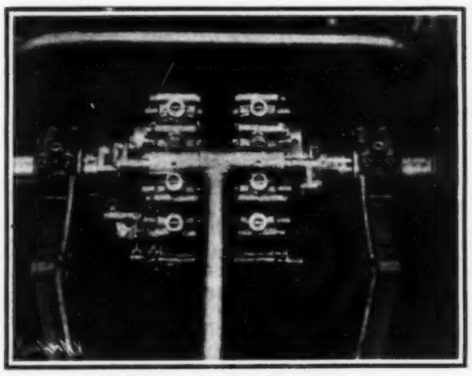
on each side of the forward end of the valve are compressed, while the other two springs on the rear side are extended, and so on alternately, according to the forward or backward stroke of the piston. During the stroke the valve is tripped to mid-position, thereby cutting off the steam to the D valve. At the end of the stroke the two valves move together, and admit steam to the cylinder. If required, the piston valve can be cut out entirely.

The boiler is of a specially designed water-tube type, combining the good points of both the fire-tube and the semi-flash boilers. It supplies superheated steam at a regular temperature.

Differential gearing is completely dispensed with, since in turning the outer road and its ratchet wheel are permitted to run faster than the inner road and ratchet wheel, owing to the outer ratchet wheel slipping past its pawls. As there are no dead centers to the engine, the vehicle can be stopped and restarted easily on the steepest gradient, while the constant engagement of the pawls with the ratchet wheels prevents any possibility of the car accidentally running backward down hill.

The vehicle is provided with powerful steam brakes engaging with the rear driving wheels, and these can be operated by either the driver or fireman, as there is a wheel provided on each side of the footplate for the purpose. At the rear of the vehicle, which has a wheel base of 11 feet 6 inches, is carried the water tank, having a capacity of 200 gallons of water. The wheels are also of special design, the tires comprising wooden blocks, which can be easily and quickly removed when renewing is desired, while at the same time they are of such a design as to prevent slipping on wet and greasy road surfaces.

Owing to the simple nature of the driving mechanism, a great economy in the weight of the vehicle has been obtained, so that it has been possible to construct it more lightly than is possible with the prevailing



THE HAY STEAM LORRY, SHOWING UPPER CONNECTING ROD AND UPPER PART OF PAWL CASES.

type of steam-propelled vehicle, yet at the same time possessing an ample factor of strength. The whole of the motion comprising the pawl cases and ratchet wheels runs in an oil bath, and perfect quietness and sweetness in running are obtained. The continuous alternating motion of the upper and lower connecting rods and their pawl cases imparts a steady, continual rotary motion to the ratchet wheels, so that all shocks at the piston strokes are completely overcome.

THE MANUFACTURE OF PLASTER OF PARIS OR STUCCO.

The gypsum rock should first be crushed down to about one-inch cubes with some first-class crusher, preferably a jaw crusher. As the rock is mined in large pieces, the opening of the crusher should not be less than 20 x 12 inches.

The crushed gypsum rock should then be dried in a rotary direct-heat dryer. The products of combustion used in drying this material should not pass through the material on account of the danger of coloring it, and the drying should be done on the outside of the dryer only. Connected with the dryer, there should be a good dust-settling chamber to save the dust, which is valuable.

After the gypsum is thoroughly dried it should be again crushed in an ordinary pot or bowl crusher, and should then be ground to pass an 80-mesh screen. French burr mills are generally used for this fine grinding, and are, no doubt, satisfactory, although other ways for grinding are used in many places.

The ground gypsum is then passed into a calcining kettle, which is usually about 8 feet in diameter and 8 feet high, and which has gears, flues, a fire front, and grates and doors, and also an upright shaft and stirrers near the bottom driven by heavy gears from above. The ground material is slowly passed into the calcining kettle where it soon begins to boil, material being added gradually until the kettle is full. From the crushed and thoroughly dried gypsum rock a batch can be calcined in about one and one-half hours, the time depending on the dryness of the material and the quantity of the finished product.

The raw material usually contains enough moisture so that it will thoroughly boil for a short time, the boiling will subside for a while, and then a second boiling will occur, and in some cases even a third. The more the plaster boils the quicker it will set. For ordinary plaster work but one boiling is required, but for fine work or plaster of Paris, two boilings are necessary.

The chemical change takes place in this calcining kettle. After being sufficiently calcined or boiled, the calcined mass should be immediately emptied into hoppers or bins made of brick or iron, after which it is ready to be conveyed to the storage bin, where it is packed in barrels or sacks and is ready for the market. As soon as the kettle is emptied another charge should be put in.—Mines and Minerals.

THE MOON'S POSITION.

From preliminary experiments at the Helwan Observatory, Egypt, E. B. H. Wade has obtained promising results in the endeavor to record the moon's position among the stars. The following description of the experiments appears in the Royal Astron. Soc. Monthly Notices:

A photographic camera is mounted so that its optical axis passes horizontally through the center of an ordinary cœlostat, but the mirror of the latter, instead of being worked to a true plane, is figured as a prism, the two faces of which are inclined to an angle of 72 deg., and the edge of the prism is arranged parallel to the polar axis. The camera will then receive light from two regions of the sky situated 15 deg. apart in right ascension. The cœlostat is then adjusted to reflect the moon from one face of the prism and stars from the other into the camera. The stars are exposed

for 2½ minutes, the moon being intercepted meanwhile, then the moon is exposed for a fraction of a second and again intercepted, while a further exposure of 2½ minutes duration is given to the star field. By this method, Wade has obtained a number of successful results, using a 4-inch cœlostat prism mirror, in conjunction with a 2-inch Dallmeyer telescope lens.

THE ULTRAMICROSCOPE AND ITS CHEMICAL APPLICATIONS.

By DR. L. MICHAELIS.

THE ultramicroscope is an apparatus which in one respect very greatly increases the power of the most perfect of ordinary microscopes. While the lower limit of visibility with the ordinary microscope is about 0.2μ, it is possible to detect with the ultramicroscope objects of a diameter estimated to be less than $4\mu\mu$. (A micron, denoted by the symbol μ, is one thousandth of a millimeter or approximately 1-25,000 inch. The symbol $\mu\mu$ denotes one millionth of a millimeter or 1-25,000,000 inch.)

The limitation of the capacity of the ordinary microscope is absolute, so that no increase of the theoretical magnifying power can make visible an object smaller than the limit quoted. We may explain this fact by assuming that the waves of light bend around and meet behind very small objects. In the illuminated field of the microscope an opaque object betrays its presence, size, and shape by cutting off the light in a certain portion of the field, but an object so small that the light waves reunite immediately behind it cuts off no light and consequently remains invisible, no matter what the power of the instrument. Helmholtz and Abbe have calculated that this limit of visibility is equal to half the wave-length of light. The shortest waves that affect the eye, the waves of violet light, are about 0.4μ in length, therefore no object whose diameter is less than 0.2μ or about 8 millionths of an inch can be seen in the most powerful microscope. This limit can be reduced, though not very greatly, by the employment of ultraviolet light and Koehler's ingenious photographic apparatus, as ultraviolet light has no direct effect on the eye.

The ultramicroscope is constructed upon an entirely different principle. The story of its invention runs as follows: Richard Zsigmondy was engaged in a study of the peculiarities of ruby glass—a deep red but perfectly transparent variety which is made by melting together glass and metallic gold. When a sunbeam, brought to a focus by a convex lens, is thrown upon a block of ruby glass the converging pencil of light within the glass becomes luminous and visible like a sunbeam traversing cloudy water or air filled with dust. This phenomenon led Faraday to conjecture that the ruby glass owed its color to extremely small particles of gold scattered through its substance. As these supposed particles are not revealed by the microscope, their dimensions must be less than the Helmholtz-Abbe limit of visibility.

The experiments of Fizeau and Ambronn, however, had proved that under conditions of illumination different from those which are customary in microscopic observations the light which emanates from very much smaller objects can be perceived. For example, when a silvered glass mirror is held between the eye and the sun it is possible to detect scratches in the coating the width of which is much smaller than the assumed limit. And against the dark background of the sky stars are seen whose diameters are so small that they appear as points of light in the most powerful telescopes. In these cases what is perceived is not the "counterfeit presentment" of the object but merely an impression of light. Triangular stars would present exactly the same appearance as round ones.

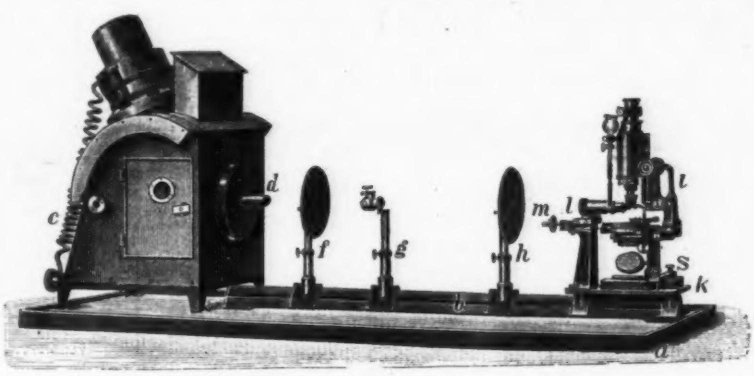


FIG. 1.—ULTRAMICROSCOPE ARRANGED FOR THE STUDY OF LIQUIDS AND COLORED GLASSES.

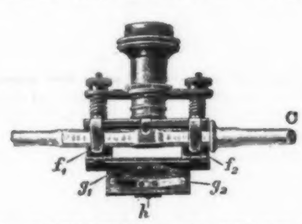


FIG. 2.—OBJECTIVE AND STAGE WITH LIQUID CONTAINER.

In other words, we can see luminous objects of almost infinite smallness, in the sense of perceiving their light, if they are very bright and have a dark background. The law of Helmholtz and Abbe applies only to the formation of distinct images of objects and sets no limit to the size of a luminous object that can be detected under favorable conditions. Zsigmondy reasoned that if the particles of gold in ruby glass could be made luminous they would become visible in this restricted sense. There is no difficulty about making the particles luminous. The experiment with the sunbeam and the condensing lens indicates one way of doing this but it is evident that the glass should be viewed from the side and not in the direction of the beam of light as objects are usually viewed through the microscope. Zsigmondy, accordingly, illuminated a block of ruby glass with a converging pencil of light and examined it with a microscope the tube of which was perpendicular to the pencil. He found that a comparatively low power sufficed to show the separate particles of gold, shining in the dark field like countless stars.

This is the whole secret of the ultramicroscope but its development into a practical optical instrument required many calculations and experiments, which were made with perfect success by Karl Siedentopf, at the Zeiss optical works at Jena. Fig. 1 shows Siedentopf's arrangement of the apparatus. An electric arc lantern, *c*, sends a beam of light through the tube, *d*, to the condensing lens, *f*, at the focus of which is placed a slit, *g*, which can be regulated to admit a beam of any desired width. The lens, *h*, forms a reduced and inverted image of the illuminated slit at a point near the lens, *l*, through which the rays pass into the glass tube, *C*, placed under the object glass of the vertical microscope. This tube, shown on a larger scale in Fig. 2, may be filled with any liquid or it may be replaced by a suitably cut block of ruby glass. The glass or liquid is thus illuminated by a concentrated horizontal pencil of light and is observed from above.

FIG. 4.—APPEARANCE OF DILUTED BLOOD SERUM IN THE ULTRAMICROSCOPE.

For the study of other objects the apparatus is modified as shown in Fig. 3. Here both the beam of light and the microscope are horizontal and an entirely different device is adopted to prevent the entrance into the microscope of light coming directly from the lantern. The central part of the objective is blackened and before it is placed a system of lenses so arranged that the direct beam is converged upon the blackened part. The object is fastened in the usual manner between a glass slide and cover. The only rays that can enter the microscope are those that are bent aside, or diffracted, by the object so that they fall upon the peripheral uncovered zone of the objective. The ultramicroscope can easily be converted into an ordinary microscope by substituting an Abbe condenser for the system of lenses described above. The covering of the center of the objective represents the perfect development of the principle of "dark stage illumination" which, as hitherto applied, was incapable of furnishing results comparable with those obtained by means of the ultramicroscope.

The most interesting chemical application of the ultramicroscope is to the study of colloidal solutions, such as solutions of albumen, glycogen, the colloidal metals and many dye stuffs, which do not appear, even to the naked eye, as clear and transparent as solutions of crystallized substances. Seen by transmitted light they appear transparent, unless they are very deeply colored, but a cone of light projected into the solution by a lens is brightly luminous and the light emitted by it has been shown to be polarized. From these facts alone it may be inferred that the light is reflected by minute suspended particles and the truth of this supposition has been confirmed by the ultramicroscope. Colloidal solutions of gold, examined with this instrument, present an appearance similar to that of ruby glass except that the innumerable bright points, in the solution, have very rapid proper motions both of oscillation and of translation. They dance to and fro and also progress in straight or zigzag lines. The motion resembles the so-called "Brown's molecular motion" which the microscope reveals in particles of India ink suspended in water. In both cases the movements are probably due to the same repulsive forces between the suspended particles that prevent their falling to the bottom of the solution. The colloidal solution of gold appears red by transmitted light but the luminous particles appear green in the ultramicroscope. The explanation of this is that the rays of light for which the particles of gold are transparent are necessarily absent from the light which those particles reflect laterally. In many other cases the color of the particles revealed by the ultramicroscope is complementary to the color of the liquid as seen with the naked eye by transmitted light. When the colloidal gold solution is coagulated by the addition of soluble salts the particles coalesce, becoming brighter and less numerous, until they attain ordinary microscopic size and are precipitated.

Siedentopf and Zsigmondy determined the size of the suspended ultramicroscopic particles by counting the number in an accurately measured small portion of the field of view, and determining by chemical analysis the quantity of gold contained in an equal volume of the solution. Different values were thus found for different solutions of gold. On the assumption that the particles were cubical the smallest value found for the average thickness of particle was $6\mu\mu$ (about 1-4,000,000 inch), and the largest was $40\mu\mu$ (about 1-600,000 inch). Particles larger than the latter could not be kept in suspension without the addition of gelatine or some other ordinary colloid.

But there is no warrant for the assumption that the gold particles are cubical or in any way symmetrical about centers. On the contrary, there is every reason to believe that they are either flat plates or needles, though the ultramicroscope gives no direct indication of their actual form. Siedentopf's ultramicroscopic study of colored rock salt crystals throws a good deal of light on this point. Such crystals are occasionally found in nature and salt crystals can be artificially colored by exposing them to sodium vapor or by ionizing them, with the separation of free sodium, by means of Roentgen rays or electricity. The color appears to be due to the presence of finely divided metallic sodium. When examined with the ultramicroscope these colored salt crystals were found to contain multitudes of extremely fine particles, which resembled in appearance the gold particles of ruby glass, except for the fact that they were arranged in regular order.

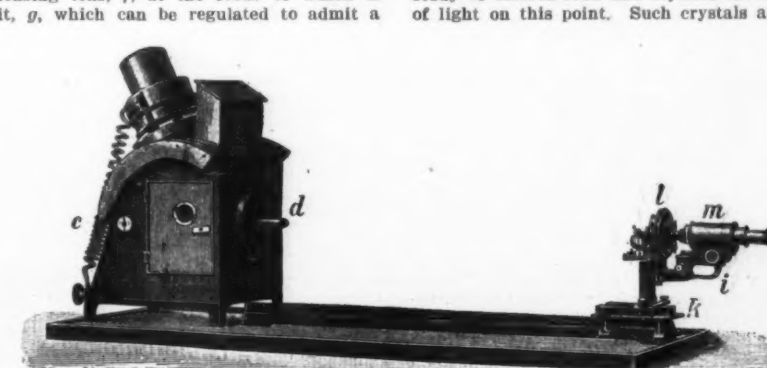


FIG. 3.—ULTRAMICROSCOPE ARRANGED FOR STUDY OF OBJECTS MOUNTED ON SLIDES.

The sodium particles, like others shown by the ultramicroscope, were found to emit polarized light, but the plane of polarization was not the same in all cases and its variation, interpreted by the theory of optics, led Siedentopf to the conclusion that the particles were of different dimensions in different directions, resembling in form needles rather than cubes or spheres.

Solutions of dyestuffs form another group of objects for the ultramicroscope. The boiling points and other physical properties of many such solutions indicate molecular weights far too high to agree with the known chemical constitution of the dyestuffs, and this discrepancy has suggested the conjecture that these bodies form colloidal rather than true solutions. The ultramicroscopic study of dyestuffs, begun by Siedentopf and Zsigmondy and continued by Raehlmann and the writer, shows that these substances can be divided into several classes according to their optical behavior.

The first class comprises dyes the solutions of which exactly resemble colloidal solutions of gold. In the ultramicroscope the particles of most of these dyes appear as points of light of colors complementary to those of the dyes. This effect is particularly striking in the cases of "soluble Prussian blue" and many organic dyes of great molecular complexity, such as indulin, nigrosin, or "violet-black." In very dilute solutions of Prussian blue the ultramicroscope reveals a dense swarm of copper-colored luminous points on a dark background. On the other hand there are dyes which even the ultramicroscope fails to resolve into separate particles. All the fluorescent dyes belong to this class. They fill the field of the ultramicroscope with a uniform diffused light, the color of which is that of fluorescence, not that of the dye itself.

Fluorescent solutions strongly resemble cloudy liquids. A concentrated beam of light passing through either is visible and brightly luminous and it might be supposed that each would present practically the same appearance in the ultramicroscope. This, however, is not the case. There is another important optical difference between a cloudy and a fluorescent liquid. A beam of light diffuses polarized light when it traverses the former but unpolarized light when it traverses the latter. This proves that fluorescence and cloudiness are essentially dissimilar, and that the particles which cause fluorescence are of a far smaller order of magnitude than even the particles of colloidal solutions of metals.

The dyes of the third class are intermediate in character between those of the other two classes. In the ultramicroscope their solutions show luminous particles but these particles are not sufficiently numerous to account for all of the dyestuff. Fuchsine and methyl violet belong to this class. Even a solution of one part of fuchsine in 1,000 parts of water shows very few particles. In this case part of the dyestuff exists in the state of a true solution, homogeneous and not optically resolvable, and the remainder consists of particles held in suspension in the aqueous solution. The equilibrium between the two parts can be disturbed by the addition of various substances, such as common salt, which increase the suspended and diminish the dissolved portion. The dyestuff can be entirely "salted out" by adding a large quantity of salt. Histologists, following the example of Ehrlich, have been accustomed to employ aniline water and other organic substances to increase the tinctorial effect of aniline dyes. The ultramicroscope shows that such additions to an aqueous solution of fuchsine greatly increase the proportion of dyestuff in suspension. Nearly related to this phenomenon is the well-known fact that old fuchsine solutions are easily precipitated. But it would be erroneous to infer that the portion of the dye that is visible as distinct particles in the ultramicroscope is the portion that is taken up by the fibers of yarns and fabrics. On the contrary everything goes to show—the evidence cannot be given here—that only the dissolved part of the dye which is not revealed by the ultramicroscope possesses any coloring power. The dyeing of fabrics and the condensation into grains of ultramicroscopic size are two almost identical expressions of the same fundamental property—the tendency of the dyestuff to escape from the state of true solution.

A few other examples from the chemistry of dyes will serve to show the capacity of the ultramicroscope in the proper light.

When sodium hydrate is added to a very dilute solution of the violet blue dye thionine (Lauth's violet) the red thionine alkaloid or base, of which the dye is a salt, is set free. Although this base, properly speaking, is insoluble in water it is not precipitated from an extremely weak solution of the dye but forms, apparently, a homogeneous red solution which long remains unaltered in darkness, though it soon coagulates if exposed to sunlight. The ultramicroscope, however, shows that the red thionine base is not dissolved but merely suspended, in the form of extremely fine particles. The blue solution of the thionine dye, on the other hand, exhibits uniform unpolarized red fluorescence, without particles, in the ultramicroscope. Hence it appears that the salts of thionine form true solutions, but the base itself forms an ultramicroscopic suspension in water. But the solution of the thionine base in toluol is a true solution which exhibits fluorescence, but no granular structure in the ultramicroscope.

The ultramicroscope, therefore, shows that dyestuffs occupy an intermediate position between crystalloids and colloids. To some extent they form true solutions but in various circumstances they show a strong tendency to assume the character of very fine grained suspensions.

The albuminoids form another field of ultramicroscopic research. Even to the naked eye their solutions appear opaque but the ordinary microscope fails to reveal the cause of their opacity. When a very weak albuminoid solution, such as diluted blood serum, is examined with the ultramicroscope the field appears strewn with very fine, moving points of light (Fig. 4). In undiluted serum the particles are crowded too closely together to be separated by the ultramicroscope and the field is filled with uniform diffused light. To the limit of size of objects visible in the ordinary microscope corresponds an equal limit of distance between particles that can be distinguished by the ultramicroscope. If this distance is less than the Helmholtz-Abbe limit, the cloud of particles cannot be resolved into its elements. Hence it is necessary to dilute the solution copiously in order to increase the distance between the particles.

As the particles revealed by the ultra-microscope are exceedingly fine, approximating to the dimensions which are attributed to the more complex molecules, they were at first supposed to be the molecules of albumen, but this supposition has been disproved by the observations of Raehlmann and the writer. If a solution of albumen, so dilute that only a few particles appear in the field of the ultramicroscope, is boiled and again examined, the number of particles is seen to have increased greatly. Furthermore, the particles are much more numerous in blood serum diluted with distilled water than they are in serum diluted to the same extent with a 9 per cent solution of common salt.

Now, as boiling produces a precipitate of coagulated albumen, and the addition of distilled water precipitates globulin, it is evident that the increase in the number of particles in suspension simply indicates the commencement of precipitation. The albumen, like certain dyestuffs, must be regarded as partly dissolved and partly suspended in the water. The ratio between the dissolved and the suspended portions depends upon the amount of salt in the solution and many other circumstances. The particles visible in the ultramicroscope, however, are conglomerates of many molecules.

The ultramicroscope also reveals numerous particles in solutions of glycogen, but when a sugar-forming enzyme (saliva) is added, the particles gradually disappear as saccharification progresses.

In solutions of pure sugar and of crystallized compounds of even very high molecular weight the ultramicroscope, like the ordinary microscope, reveals no trace of structure.

All these investigations of liquids and colored glasses have been made with the first form of the apparatus (Fig. 1). The second form, with the blackened object glass (Fig. 3) is adapted to the examination of small objects mounted in the ordinary way between glass slides. Let us consider, in the first place, how a simple object of microscopic size, such as a red blood corpuscle, appears in the ultramicroscope. As the same lenses are used there is no increase in magnification, but the appearance is entirely different. Instead of a simple circular contour we see a number of concentric rings, caused by diffraction, so that the outline is multiple, like that of an island on a chart. Two disks, nearly in contact, appear in the ultramicroscope as a figure 8, with several contour lines, and objects only slightly more complex give rise to an inextricable tangle of diffraction curves. Applied to such objects the ultramicroscope is only a source of confusion and consequently there is no hope that it will increase our knowledge of the structure of animal cells or the like. At present few objects visible with the microscope are known which may be studied to advantage with the ultramicroscope. For example, if a blood corpuscle contains a few widely separated particles (as occurs in certain diseases) these extremely small objects can be detected by the ultramicroscope because they will be apparently increased in size by the diffraction rings around them. In other similar cases the ultramicroscope may be employed with advantage, if the observer bears in mind the deformation which it produces.

In conclusion, the subject of micro-organisms which cause disease must be mentioned. Many of these are so small that they are invisible under the microscope and pass through sand filters which retain ordinary bacteria. The germs of yellow fever and the foot and mouth disease of cattle are of this order of magnitude. At first it was hoped that these organisms could be discovered with the aid of the ultramicroscope but the hope has not been realized. As the ultramicroscope does not give the form of an object it would be very difficult to distinguish between these micro-organisms and albumen particles, nor could they be detected by their movements for we have seen that the lifeless particles of albumen are also endowed with rapid independent motion.

These problems, however, do not belong to chemistry.—Translated for the Scientific American Supplement from Zeit. für Ang. Chemie.

Watt's life is one that can be read with profit by every engineer, and the lessons which it teaches of patient industry and a determination to study not only the actual details of the work, but also all the allied natural forces, which (some of them) appear at first sight hardly to be cognate to the profession of an engineer. He educated himself in more than one European language, and from his training at Glasgow shone as one of the accomplished men of his time; and at his death, in 1819, his merits were recorded by a statue in Westminster Abbey.

NOTES ON TWO-CYCLE MARINE ENGINES.

By D. W. Gawn.

The first question to be answered in considering the engining of a motor-boat is whether the motor itself shall be of the four-cycle or two-cycle type. There is much to be said in favor of both of these for boat-propulsion; but, unfortunately, among British users at least, the two-cycle engine is looked upon with a good deal of prejudice—a prejudice that certainly is as unfair as it is unwise. Compared with the four-cycle engine, the other is by far the more simple, light, and durable, and, in that kind compressing the air to a high pressure before the introduction of fuel, it may also be said to be the more economical and safe. It is well understood that a comparatively slow speed is preferable in a marine motor, and this, of course, is one of the essential qualities of the two-cycle engine. It is generally admitted, too, that a fairly even torque is wanted to drive a propeller at its best and with a minimum of vibration, and this, again, is one of the essential qualities of the two-cycle engine. A four-cycle motor can be designed to run equally well either at a high or a slow speed; but if the latter, it will necessarily be at the expense of great weight and bulk. The two-cycle engine is, on the other hand, purely a thing of slow speed; but, while being so, it need not be excessively heavy nor large for the power to be developed.

Unquestionably, the chief advantage of the two-cycle engine for marine work is, however, its extreme simplicity and, therefore, its adaptability to conditions prevailing in a general way. It does not demand skilled attendance as, to a large degree, does the four-cycle engine for successful running; nor has it attached to it anything like such a catalogue of possibilities of failure. In an engine that has but one cylinder, a piston, a connecting rod, a crankshaft, a crankcase, and a flywheel to be all but complete, there can be few chances of breakdown. Gear wheels, cams, valves, and even ignition apparatus in any shape or form are, or can be, dispensed with entirely; and it is conceivable that their absence may make for little short of a blessing under certain circumstances.

The system of compressing the air in the cylinder to a high pressure, and then injecting the fuel by means of a pump or other device, as in the Diesel engine and others is, undoubtedly, the most rational and efficient that can be employed. For marine engines, at any rate, no other method of working can approach it in all-round excellence. In designing such an engine it is simply necessary to allow for an unusually high compression—anything between, say, 250 pounds and 400 pounds per square inch—and, preferably, to arrange for the admission of fuel under pressure at that moment when ignition is desired. The heat developed in compression will be high enough to fire the oil injected, which, by the bye, may be ordinary kerosene or almost any of the crude oils that are obtainable so cheaply in bulk. Provided the feed is right and the compression sufficiently high, combustion will be practically perfect at all loads and no fouling will occur. The pump obviously will be very small, since only a minute quantity of oil is to be passed per stroke in any but the largest engines. It must, at the same time, be solid and strong, and, it goes without saying, as simple as it can be made. An eccentric may be used to drive it off the crankshaft. There are many ways by which the oil can be admitted at any given moment, instead of occurring with and as long as the pump-stroke period. Perhaps one of the simplest and most certain is to let the pump have an air-chamber, and at any convenient position in the delivery-duct, to fit a valve capable of being "timed," as the spark is in an ordinary motor. This should make for a flexibility of running much superior to that of the usual two-stroke engine. Contrive a trip gear to disconnect the pump altogether when normal engine speed is exceeded.

The exhaust port must be amply large, and it should be so situated that it is at least partly uncovered by the piston before the inlet port begins to open. To avoid any complication or irregularity in the cylinder casting, both these ports can be set in line although diametrically opposite, the opening of one before the other being accomplished by giving a slight slant to the top or back of the piston. It is advisable to make both ports as short in the longitudinal direction of the cylinder as practicable, that the piston may be driven nearly to the end of each stroke ere opening them. The following formula may be used in determining the area of the exhaust port: $\frac{A\,S}{3{,}000}$, where A = the piston area in square inches, and S = the piston velocity in feet per minute. The inlet port can be rather smaller, and for this purpose the above rule will serve if the divisor is increased to 4,000.

In the designing of the moving parts, where compression is very high, while lightness is as desirable as ever, extra stiffness is also wanted. The piston need not be any heavier than usual, provided that the head is well supported by webs; but the gudgeon pin should be much larger than is commonly the case. In an engine recently designed, the writer so far departed from ordinary practice as to adopt a sort of knuckle-joint between the connecting rod and the piston, whereby the bearing surface was largely increased and lubrication made more certain and easy. Something of the kind would appear to be most necessary, seeing what has to be borne at this point. Generally a two-cycle engine will run well with a comparatively light flywheel; but where high compression is employed,

the wheel must needs be fairly heavy. Probably one such as would be fitted to a four-cycle motor of similar power will satisfactorily answer all requirements, and thus the usual rules for computing its weight may be adhered to. Let it be borne in mind that it is better to err on the side of heaviness than otherwise, if any error at all is to be made. In many a so-called high-class engine the flywheel is absurdly proportioned—a defect for which there is seldom the slightest excuse.

In two-cycle engines of the class more commonly met with, wherein the charge of carbureted air is drawn into the crankcase and compressed for transmission to the cylinder, the correct placing of the ports in the cylinder becomes more important than ever. When pure air is forced into the cylinder there can be no risk of firing back into the crankcase; but with an explosive mixture to be dealt with the matter is very different. The hot exhaust gases will immediately fire the ingoing charge if this is admitted too early, or, what amounts to the same thing, the burnt gases are retained too long; but, clearly, the exhaust cannot be got rid of till late in the firing stroke without sacrificing power materially. And, for the same reason, must the inlet be effected quite early in the compression stroke. It were better on the whole, perhaps, to sacrifice some power directly rather than indirectly, and have continual trouble with back-firing; and, with this view, the exhaust may be timed to take place fairly early. This, admittedly, is where the opponent of the two-cycle engine has the best of the argument, for certainly something must be lost if the exhaust and inlet are to be effected anywhere but within a few degrees either side of the dead point. As stated, this trouble is not nearly so pronounced in those engines admitting air and fuel separately, and a properly-designed engine of that class will not easily be beaten.

Some trouble is often experienced in two-cycle engines from oil being blown out of the crankcase. The stuffing-box kind of bearing sometimes used to overcome the difficulty, as well as to prevent "loss of compression," is not by any means to be advised. Nothing short of flooding with oil will save such a bearing heating up, and as this cannot reasonably be done, the thing is hopeless. Much more effective and reliable is to give the bearings a good length, and to let them be of the ring-lubricator type, so that little air can escape, and any oil forced outward along the journals will drain off into the reservoirs, instead of reaching the outside of the bearings.

Take care always to keep the crankcase as small as it is possible to make it. If of large capacity, rambling and irregular in outline, the piston will fail to compress the charge sufficiently high to enable it to drive out the residual gases from, and fill, the cylinder during the brief period that the inlet port is opened. In reason, the higher the crankcase pressure, the better will the engine run. By the way, if the crankcase is made in two halves, let it be the lower half to have the supporting brackets or feet, so that, when required, the engine can be taken down without pulling it right out of the boat, and disturbing the shaft and its connections. Many designers appear to forget that a motor is a thing to be used, and that, in all probability, the user will be human.

Some little difficulty is supposed to be introduced, as a rule, where more than one cylinder is to be employed, as then it becomes necessary to divide the crankcase into as many more or less airtight sections as there are cylinders. But if the crankcase is cast in two parts, as usual, with the mere addition of "bulkheads" to form the required sections, each division having a wide joint-face and proper provision for carrying the crankshaft, there will not be much to worry about as regards the result.

A stroke somewhat in excess of the bore will be found more satisfactory than equal bore and stroke. The reason, as before mentioned, is that part of each power-stroke will necessarily be lost so far as its effectiveness is considered. Such proportions as 3½ inches by 4 inches, 4 inches by 5 inches, 4½ inches by 6 inches, etc., answer well enough. Let the compression in the cylinder be fairly high on the whole, as each charge will be to a certain extent diluted by previously burnt gases, and, therefore, call for good compression to make it really effective in firing. A pressure of from 75 pounds to 90 pounds per square inch is ordinarily suitable, according to size and design.

The three-port system of distribution by which an inlet-valve in the crankcase is dispensed with cannot but be viewed with disfavor. On the up-stroke of the piston it tends to create a vacuum in the crankcase, of course, till a port in communication with the carbureter is uncovered and a charge rushes in. But, as a matter of fact, this vacuum must be more imaginary than real, on account of leakage, and very little suction indeed is likely to be induced through the carbureter when the moment for it to act arrives. This is self-evident. If an ordinary carbureter is to be employed, connect it up with the intermission of a light check valve direct to the crankcase. Governing may be effected very readily and efficiently then by providing a mechanically controlled leak-valve arranged to open when normal speed is exceeded, and therefore completely cutting out the automatic inlet-valve till the speed drops again. The common type of carbureter is not, however, a necessity nor a desideratum. There must needs be a lead cast in the cylinder, or a short pipe on the outside to convey thereto the charge compressed in the crankcase. It is not by any means difficult to introduce into this a governor-controlled fuel jet, so that the air does not become carbureted until on the actual point of entering the cylinder for the final compressing. Fuel is entirely cut off by the governor if the speed exceeds the set rate; but a constant supply of pure air is circulated right through the engine so long as it runs by its own momentum, carbureting being resumed as soon as power is wanted again to maintain normal speed. This air acts a good part in scavenging and cooling the cylinder as the governor comes into action. The system has much to recommend it, and deserves to be widely adopted.

In the matter of electric-ignition apparatus recent experience has induced the writer to alter some previous opinions. There cannot be any doubt that the low-tension magneto is at present more suitable for use on the water than other forms of ignition appliances. Its powers of endurance under trying conditions are remarkable when well designed throughout. A good deal of wetting and rough handling is wanted to put it out of service altogether. The magneto-machine itself will presumably be bought ready for use; but such fitments as are needful for the connecting-up or driving gear, strikers, sparking points, etc., the designer of the engine must look to. Let him bear in mind that simplicity and solidity are the first qualities required, since on them depend principally efficiency, reliability, durability.

As an alternative means of ignition, dry cells and a "trembler" coil or coils, with a wipe contact-breaker on the crankshaft, can be advised. These cells, when good, are most convenient for marine work. Even if the magneto is employed nominally, there should be a battery of cells and a coil on board to serve as a "stand-by."—Eng. Mch. and World of Science.

ELECTRICAL NOTES.

A few years ago the question of motor driving was considered entirely on the basis of saving in power. Much ingenuity was spent in computing power losses in line shafting, belts, and countershafts and in determining the precise points where saving in power was offset by increased investment charges. It is undeniable that the loss in transmitting power electrically, except over short distances, is less than with mechanical transmission, especially as the amounts of power became large; and, when the driven units are few and large, the first cost of motors and wiring may be no greater than the cost of shafting and hangers. The motor-drive problem then becomes comparatively simple. But with greater subdivision and smaller absorbing units the first cost is increased enormously. Not only are small motors relatively more expensive than large ones, but the number of motors standing idle or running lightly loaded at any time is greater. The total motor capacity for the plant is therefore much increased, even three, four, or five times. For these reasons applications of motors to the driving of factories were at first confined to the class known as "group" driving, in which a few good-sized motors drive independent short lengths of line shafting to each of which a group of machines is connected by means of belts and countershafts.

Electrical phenomena accompanying the decomposition of ammonium were made the subject of a very interesting investigation by A. Coehn. When the metal ammonium decomposes into the non-metals ammonia and hydrogen, a suppression of the dissociation of the electrons within the substance takes place. If this occurs suddenly, electrons should escape and cause effects similar to those produced by radio-active substances. By an appropriate arrangement in connection with a quadrant electrometer of the Dolezalek pattern, it is shown that when ammonium amalgam, produced by the electrolysis of a solution of an ammonium salt, decomposes, it gives out positive particles, and becomes negatively charged itself to the extent of 7 volts. The expulsion of positive particles is accelerated by charging the amalgam positively, and hindered by a negative charge. Rise in temperature exerts an influence, in that it increases the velocity of decomposition of the amalgam. The effect is shown not to be due to vapors of ammonia, nor to gas-bubbles which may escape from the surface of the amalgam. A mixture of ammonia and hydrogen bubbling through mercury does not produce any effect. Sodium and potassium amalgams do not behave in a similar manner; if, however, these amalgams are dipped into a solution of an ammonium salt, thus producing an ammonium-potassium or ammonium-sodium amalgam, an effect is produced, but not nearly so marked as with the pure ammonium amalgam.

According to J. Trowbridge, in the Proceedings of the American Academy, several discharge phenomena hitherto unknown may be obtained by combining strong and steady currents with high potentials and strong magnetic fields. Trowbridge used kathodes in the shape of iron rods, excited by coils carrying a current of 25 amperes wound outside the vacuum tubes. At certain pressures where the free path of the molecule is short, the violet kathode-light is repelled to the edge of the circular disk forming the kathode by a magnetic field the lines of which are directed along the lines of electric discharge, and revolves with a speed depending upon the pressure of the rarefied air. This is a distinct case of unipolar rotation. When the anode is made the core of an electromagnet at high pressures, the discharge is separated into two—one a violet discharge, the other a rose-colored discharge. These discharges are brought to the center of the disk constituting the end of the anode instead of being repelled to the edge of the disk as in the case of the kathode. The experiments support the supposition that under certain conditions of free path the negative ion is diverted more readily from the line of discharge under the influence of the magnetic field than the positive ion; or, in other words, has a greater energy of movement around the lines of magnetic force than of energy along the lines of discharge; and that the reverse holds for the positive ion. When the kathode forms the end of a powerful electromagnet under suitable conditions the output of Röntgen rays is greatly increased. When the anode in a Röntgen-ray tube is also the end of a powerful electromagnet the application of the magnetic field results in the production of Röntgen rays from a tube which cannot be excited without the application of heat. The use of condensers in the case of low-potential coils greatly modifies the effect of the application of the magnetic field, while with coils giving sparks of over 25 centimeters with comparatively large condensers in circuit, the application of the magnetic field to either anode or kathode results in greatly increased production of Röntgen rays. The application of a strong magnetic field at the anode, with lines of force along the lines of electric discharge, forms a safe and useful method of regulation of Röntgen-ray tubes. A magnetic field applied at a suitably-placed anode constitutes a magnetic rectifier for alternating currents.

SCIENCE NOTES.

As the higher grade of engineering education is an integral part of the college work, so secondary technical education should be an integral part of the high school education. The commissioned officers of an industrial army may be trained in colleges of engineering, but another school is necessary for the sergeants, corporals, and intelligent enlisted man. This department has been explored only to a slight extent. We may expect rich harvests when the ground is more thoroughly cultivated. The work of the agricultural college in giving short courses to farmers, and in holding farmer's institutes, is only an extension of the regular technical work to the needs of the agricultural industry. It is a most commendable effort, is in thorough harmony with the advancing spirit of the times, and can be productive only of good.

As the result of practical experiments in cross inoculation, on the one hand, and of close morphological study, on the other, some investigators have long claimed that there are racial or specific differences between the organisms producing the tubercles on the roots of certain leguminous plants. From the results obtained by Moore (in the U. S. Department of Agriculture) which have been reported, but not yet published, it follows that when an organism isolated from one host species is grown for a time artificially, under special conditions of nutrition, its host limitations are in great measure broken down, and it may produce tubercles on a variety of leguminous plants. It is likewise conceivable that in the case of certain yeasts the temperatures at which spores are formed, and the specific fermentative activities, may be changed by special conditions of cultivation.

In a recent issue of the Revue de Métallurgie appears an article by C. de Freminville on the "Influence of Vibration in Brittleness Phenomena." It seems that brittleness under shock may be in part explained as the effect of "elementary vibrations" or stress waves in the body. In the experiments described, a ball of hardened steel was dropped on flat surfaces of various materials. It is found that the height of rebound was a practically constant fraction of the height of fall, until beyond a certain height it becomes a diminished fraction. If the ball fall on a small block of steel resting on a large anvil, the block tends to rise after the ball, and thus somewhat less energy is restored to the ball than is the case when the block rests on a lump of rubber. A ball rebounds from a cemented mild steel surface just as from a quenched steel block, similar in other respects, but much better from quenched steel than from mild steel. It was observed that when a ball was allowed to fall repeatedly from the same height upon the surface of a piece of steel, there was a very slow increase in the height of rebound. Possibly this was due to the cold working of the surface, and there was an occasional exceptionally high rebound, as though the ball fell on a more thoroughly worked area.

In view of the conflicting conclusions reached by Curie and Danne and by Bronson, says W. Makower in Roy. Soc. Proc., experiments were undertaken to investigate the influence of temperature on the activity of radium emanation when in radio-active equilibrium with radium A, B, and C, and when sealed up in a quartz tube so that there was no possibility of escape of any volatile product. The results show clearly that the activity as measured by the β- and γ-rays can be changed by high temperatures. This may be due to an increase of the rate of decay of radium C at high temperatures, but may possibly be caused by an alteration in one or more of the other radio-active bodies present. The emanation of 5 milligrammes of radium bromide was sealed up in a quartz tube and its activity measured by observing the ionization produced in a cylindrical metal vessel when the tube was placed opposite its end. The α-rays were absorbed by the quartz tube and the bottom of the ionization vessel. The quartz tube was heated at intervals in a furnace, and after heating its activity was found to fall off. The emanation, however, recovered its normal value in about an hour, showing that the observed decrease in activity was not due to porosity to the emanation of the quartz tube when hot. The change in activity increases with rise of temperature, being small at 1,000

deg. C. and increasing up to 1,200 deg. The effect increases with the time of heating for about the first hour, but subsequent heating is without effect.

ENGINEERING NOTES.

Superheating in Locomotives.—In presence of the incontestable advantages of the employment of superheated steam in stationary engines, the question of its employment for railway locomotives is important, but in this application there are various difficulties. Wilhelm Schmidt, of Germany, is said to have been the first to contrive a practical superheater for railway engines. Experiments made by Lentz on locomotives furnished with the Schmidt superheater have shown that with a superheating not exceeding 230 deg. to 260 deg. C. there is a saving of 15 to 20 per cent in the cost of operation. Formerly there was great difficulty in lubricating the cylinders and fittings, but there has been a complete triumph on one hand in having recourse to mineral oils in place of vegetable oils, and on the other hand in making use of metallic linings or those of asbestos in place of the substances previously employed. Vegetable oils cannot resist high temperatures and are decomposed at about 200 deg. C., while the mineral oils, the flashing point of which is 500 deg. to 560 deg., allow of the use of superheated steam at a temperature of 360 deg. Herr Borries gives in the German publication, the Organ für die Fortschritte des Eisenbahnwesens the results of experiments made on locomotives of the Prussian state railways. Comparison was made on three similar high-speed engines. If the locomotive supplied with superheated steam consumes nearly as much combustible as a compound two-cylinder engine, and more than one of four cylinders, it, on the contrary, consumes less water. The superheating engine works remarkably well at high speed, without doubt because the steam presents less resistance in the passages. In these tests the superheated steam has given results superior to those of a previous series of experiments, and if it has burned three per cent more of combustible than the compound engine of four cylinders, it has burned ten per cent less than that of two cylinders. On the other hand, it has consumed respectively twelve and twenty per cent less water than the other engines. It must be said that there have been other tests in which a superheating engine burned two per cent of combustibles and consumed sixteen per cent of water less than a compound locomotive engine even of four cylinders. All these figures have reference to passenger trains. For freight trains the corresponding saving has been 6.80 for coal, and 8.70 for water. Though comparisons and experiments have exhibited certain divergences, it is not doubtful that superheating is advantageous. The best form of superheater for locomotive engines raises a different question, but invention is fertile, and progress will be made in that direction.

In an instructive article by H. Fischer in the Zeitschr. Vereines Deutsch. Ing. an attempt is made to show what points must be considered when designing a new steam plant, or in the case of an existing plant, how this should be conducted under the particular conditions necessary, in order that the cost per unit of energy may be as low as possible. The chief points are as follows: Moisture in the fuel to the extent of 4 per cent means an additional 30 kilogramme-calories for the evaporation of the contained water, or at 70 per cent boiler efficiency 37.5 kilogramme-calories; and since the combustion temperature is directly proportional to the calorific value of the fuel and inversely proportional to the volume of the gases, this abstraction of heat is doubly disadvantageous. The graphic recording of the various boiler costs and efficiencies at different loads is recommended, and curves illustrating the suggested method are given, from which the most economical boiler load and evaporation can at once be seen. The same process is carried out to show the effect of superheating, of condensing, and of various loads on the engine. Superheating from 178 deg. saturation temperature to 250 deg. reduced the steam per horse-power hour from 9.05 to 7.45 kilogrammes (18.8 per cent) when exhausting direct, but the coal consumption only fell from 1.12 to 1.0 kilogramme (10.7 per cent). When condensing, superheating as above reduced the steam from 6.56 to 5.45 kilogrammes per horse-power hour (16.9 per cent), while the coal consumption fell from 0.811 to 0.717 kilogramme (11.6 per cent). There is a definite vacuum at which the least amount of heat energy is required per horse-power hour. While with increasing vacuum the steam consumption fell from 7.05 to 6.05 kilogrammes the work of the air pump per horse-power rose from 0.0142 to 0.0255 horse-power. Also when the ratio of cooling water to steam consumption rose from 27⅓ times to 28.7 times, the energy required fell from 0.0144 to 0.0131 horse-power per I. H. P. The total energy consumption, on the other hand, rose from 0.0286 to 5.0386 horse-power per I. H. P. of engine. The feed-water fell from 56 deg. to 31⅓ deg. C. The heat required per horse-power at 80 per cent vacuum is hence 3,920 kilogramme-calories and at 90 per cent is 40 kilogramme-calories (1 per cent) greater. These results were obtained with a surface condenser with electrically-driven pumps. As regards the engine, while the depreciation costs per horse-power fell from 0.9 to 0.38 Pf. on increasing the load from 405 to 1,050 horse-power, the steam consumption rose from 6.7 to 8.7 kilogrammes per horse-power hour; so that with steam at 0.4 Pf. the cost of steam per horse-power hour is thus raised from 2.86 to 3.48 Pf. (8.5 Pf. = 2¼ cents).

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

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TABLE OF CONTENTS.